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A common instructional task and a set of educational environments are hypothesized for analysis of media cost data. The analytic structure may be conceptulized as a three-dimensional matrix: the first vector separates costs into production, distribution, and reception; the second vector delineates capital (initial) and operating (annual) costs; the third vector presents cost as a function of environment. Per student equivalent annual costs are estimated for airborne television, Instructional Television Fixed Service (ITFS), satellite television, UHF television, closed circuit television, video tape recordings, film, radio, language laboratories, and dial access systems. The appendix analyzes componential and operating costs for five media systems (instructional television, audiovisual media system, educational radio, learning and language laboratories, dial access), using guidelines established in Volume I of the study. Estimated costs are presented graphically with price ranges and design considerations. Researchers must examine the possibilities of cost savings in media development and consider the relationship of instructional technology to the educational system, government, and the knowledge industry. (TI)

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COST STUDY OF EDUCATIONAL MEDIA SYSTEMS AND THEIR EQUIPMENT COMPONENTS

Volume II
Technical Report

Final report • Contract OEC 1-7-079006-5139 • May 1968
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FINAL REPORT

Contract No. OEC-1-7-079006-5139

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Volume II
Technical Report

GENERAL LEARNING CORPORATION
EDUCATIONAL SERVICES DIVISION
5454 Wisconsin Avenue
Washington, D. C. 20015

June 1968

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U. S. DEPARTMENT OF
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INTRODUCTION

The purpose of this study was to investigate the cost of instructional media systems. The first objective was to provide the educator with a set of guidelines for realistically estimating the total cost of planning, implementing, and operating an instructional media system. Volume I reports on this portion of the study.

To gain the above objective, however, it was necessary first to identify and investigate a set of commonly used or proposed media systems and to develop a methodology for determining total system costs. The data collected and analyzed achieved the second objective, i.e., providing a data base for use by researchers in further studies relating to instructional media systems. A final objective of the study was to present recommendations which could result in cost savings when media systems are used. These recommendations are in the areas of media utilization, application of new technology, and educational system organization.

Volume II contains the technical material and the data collected and analyzed during the study. The analysis of the cost data is discussed and a set of cost comparison graphics is presented. Cost saving recommendations are also provided.

The media systems investigated and for which data are presented in this volume are:

- Airborne Television
- Instructional Television Fixed Service
- Satellite Television
- UHF Television
- Closed-Circuit Television
- Video Tape Recorder
- 16mm Film
- Radio
- Language Laboratories
- Dial Access

The discussion of Computer-Assisted Instruction is presented separately in Volume III because this system is still in the developmental stage.

SUMMARY OF VOLUME II

This volume of the report discusses the data collected and analyzed during the study of media costs. Since the scope of the application of a media system directly affects the cost and the comparison of costs is inescapable, a common instructional task and a set of educational environments are hypothesized.

The data collected are organized to provide a structure for analysis. This cost structure may be conceptualized as a three-dimensional matrix. The first vector separates costs into the categories of production, distribution, and reception. The second vector delineates capital (initial) and operating (annual) costs. The third vector presents the costs according to the environment.

Following the hypothesis of the scope of application of the media systems and the formulation of the cost structure, costs are estimated for each media system which was investigated using the guidelines which were presented in Volume I of this report.

Design consideration are discussed; price ranges are presented for equipment and services; assumptions are stated; and the resulting estimated costs are graphically illustrated. The estimated costs of the systems are compared and the conclusions are discussed.

This volume also reviews the possibilities of cost savings in the areas of media utilization, application of new technology, and educational system organization.

METHOD

Need for a Hypothetical Media System

A media system must be designed before its cost is estimated. The design of a media system depends upon the educational task the media system must accomplish and the environment in which it is to operate. (See "Selection of a Media System — An Overview" in Volume I of this study for a description of this process.)

To design a system for the purposes of this study, however, it was necessary to make certain assumptions about both the educational task and the variety of environments in which this system might operate. There are compelling reasons for making these assumptions.

To Make Guidelines More Widely Applicable

One objective of this study of the cost of educational media systems was to provide the educator with a set of guidelines for realistically estimating the total cost of such systems. To make these guidelines useful, it was necessary to develop a method of cost estimation that would accommodate the variations of a multiple of unique educational settings.

To Control Variables

Precise system definitions cannot be made unless precise job definitions are available and precise environments are defined. Efficient systems are designed for particular, well-defined jobs and environments. The size of the staff, the quantity of equipment and materials, and the costs associated with these differ considerably with variations in the job to be accomplished and the environment in which the system operates. Thus, even when discussing a single type of system, the costs can vary greatly depending on the use to which the system is put and the environment in which it must operate.

To Facilitate Comparison

This study is concerned with the costs of educational media systems. Any cost study which covers a number of different types of educational media systems invites the cost comparison of these systems. However, unless the systems were all designed for the same educational objectives and environment, any comparison of them becomes quite meaningless.

Some Difficulties Encountered in Designing a Hypothetical Media System

Existing Systems

Statistics on existing media systems are of little use for comparison even when the systems have the same generic description. These existing systems vary in type of environment, amount of equipment, size of pupil population, geographical area covered, size of staff, etc. Systems that might be identical in amount and type of equipment and size of staff are usually applied to many different educational problems. They are also used at different levels of intensity and at different operational efficiencies. A comparison of different systems, or even similar systems, is difficult. There is no common denominator to which each system may be related. Some method of normalizing the systems should be available to reduce the disparities between different categories of systems and between different forms of systems within the same category.

One Task, One Environment

One method of introducing common grounds for comparison of media systems would be to give all systems a common task to perform, a common student population, and a common geographical distribution. These units would limit the variables which normally have a very wide range of values. They would also aid in making estimates of variables which are somewhat intangible when they are not studied in the context of a real situation.

With respect to numbers of students and geographical area, it does not seem feasible to define a single common environment in which all systems could operate in a comparable manner. It is more practical to define a number of different size environments and cost each system in each environment.

Applying all systems to a common educational problem may aid in comparing systems, but,on the other hand,it may further illustrate their incomparability. The common task might not be compatible with the task normally assigned to each system. The student population might be too large or too small for efficient operation of a particular media system. The geographical dispersion of the students may make some systems less economical to operate than others.

Eliminating Subject Matter

This report is not intended to illustrate the relative effectiveness of different media systems with respect to subject material. If the common task were described in neutral terms with respect to subject materials, then each system could be thought of as making an equivalent effort even though they were doing somewhat different things. This might, in a sense, put all systems into the same "ballpark."

The Approach Used for This Study

In essence, the task describes "what the system is doing" and the environment describes "over what area and for how many people it is doing it". A valid comparison of media systems can be made only when a single real environment and the actual educational task are specified in detail for each case under study. To attempt this type of approach would mean the illustration of hundreds of cases consisting of different systems and their variations applied to many educational tasks over many different environments. This monumental effort would still involve some generalizations and assumptions and would only produce a larger group of system costs which might result in more confusion than clarification.

Therefore, we have chosen a general expression for the task and a small number of generalized environments to construct a framework for media costs. Hopefully, this method may reduce the errors in system comparisons. It will not eliminate them. Where a media system does not fit a portion of the model at all, it will be so indicated. Where a media system does not fit a portion of the model as well as another system, it will be costed and explanatory notes will be appended to describe the problem.

Environments Defined

Each media system is costed with respect to a number of environments. The environments are to a great extent hypothetical. However, they are models which were created after examining actual data. In particular, city and metropolitan area descriptions closely resemble the city of Washington, D. C. and its environs. The geographical areas and population densities of the other environments are similar to those found in sections of the United States.

Local District Model. The smallest environment is the school district which may vary in size from a few hundred to over a million students. The size chosen for this study was 15,000 elementary and secondary students in an area of approximately 80 square miles. Although the majority of school districts in the United States are much smaller, those with 3,000 or 4,000 students will not have the distribution problems which become extremely important in larger systems. Also, some of the media systems are too expensive (even in their smallest configuration) to be supported by a small district. However, if these smaller administrative units join together in a cooperative effort, the costs can be apportioned on a per pupil rate for each unit.

The school district used as the model consists of 14 elementary schools and four secondary schools. The elementary schools are a combination of K-6 and K-8 configurations, and the secondary schools include junior, senior, and possibly a vocational high school. For the purpose of this study, an elementary school will have an average of about 600 students; a secondary school will have an average of about 1,400 students. The student population in each environment (local, city, state, etc.) has been rounded off to form convenient numbers so that the number of students per school when multiplied by the number of schools will not produce the exact student population indicated.

The school district is irregular in shape. However, all the schools are within a circle whose radius is six miles.

The following chart summarizes the data for the local district.

Local District Parameters

Student Population (K-12)	15,000
Total Population (Approx.)	60,000
Area	80 sq. mi.
Population Density (Average)	750/sq. mi.
Radius of Smallest Encompassing Circle	6 miles
Number of Elementary Schools	14
Number of Secondary Schools	4

City Model. The city covers an area of 70 square miles and has a total population of about 800,000 with approximately 11,500 people per square mile. The shape of the city is roughly rectangular and the entire area can be encompassed by a six mile radius circle. There are 150,000 students in 136 elementary and 46 secondary schools. The city can consist of a single school district or a number of school districts which cooperate to gain efficiency and economy through the use of a common media system. The city is not the largest nor most densely populated in the United States. By way of comparison, New York City has approximately nine times the population, four times the area, and more than twice the population density of the city used in this study.

The following chart summarizes the data for the city.

City Parameters

Student Population (K-12)	150,000
Total Population (Approx.)	800,000
Area	70 sq. mi.
Population Density (Average)	11,500/sq. mi.
Radius of Smallest Encompassing Circle	6 miles
Number of Elementary Schools	136
Number of Secondary Schools	46

Metropolitan Area Model. The population of the metropolitan area is approximately two million. Its perimeter has an irregular shape and surrounds an area of approximately 1500 square miles. Because of its irregular shape, a circle with a 30 mile radius (2800 sq. mi.) is necessary to completely cover this area.

The area which contains a number of school districts has 546 elementary and 183 secondary schools with a total of 600,000 students (K-12). It is assumed that these districts would cooperate with one another for some large media projects to achieve economy of operation.

Metropolitan Area Parameters

Student Population (K-12)	600,000
Total Population (Approx.)	2,000,000
Area	1500 sq. mi.
Population Density (Average)	1400/sq. mi.
Radius of Smallest Encompassing Circle	30 miles
Number of Elementary Schools	546
Number of Secondary Schools	183

State Model. The state has a population of about 4.5 million people. It does not contain a metropolitan area as large nor as populous as described above, though about 60 percent of the population is urban. It has an area of about 40,000 square miles and a population density of about 110 per square mile. Approximately one million students (K-12) are distributed among 920 elementary and 310 secondary schools.

State Parameters

Student Population (K-12)	1,000,000
Total Population (Approx.)	4,500,000
Area	40,000 sq. mi.
Population Density (Average)	110/sq. mi.
Number of Elementary Schools	920
Number of Secondary Schools	310

Regional Model. The region is approximately a 10 to 1 extrapolation of the state, but a smaller population density is used to bring this figure closer to the national average. The region has an area of 550,000 square miles and a population of about 42 million. There are 10 million students in 9200 elementary and 3100 secondary schools. The region contains a few widely distributed metropolitan areas but no continuous corridor such as found between Boston and Washington.

Regional Parameters

Student Population (K-12)	10,000,000
Total Population (Approx.)	42,000,000
Area	550,000 sq. mi.
Population Density (Average)	110/sq. mi.
Number of Elementary Schools	9200
Number of Secondary Schools	3100

Educational Task Defined

The task used in this report is: To provide each student with material via source medium during an average of 10% of his actual instructional time. In reality, no subject is taught entirely by the use of a media system. Some subjects may not use the media system at all. More than 10% of some subjects may be presented by a media system. This task is general in nature so that it may be applied to any system. When a single system is considered for solving an actual problem, the task can be specified in terms of particular subject material and relative effectiveness of the media for that material.

A difficulty with respect to this study is not that the task is general in nature, but that it is not defined in units that have a relationship to system design. To bridge this gap, the following exercise is offered to illustrate the method used for this study to convert the general 10% task into an annual requirement for hours of unique program material for each of the defined environments. In a real situation, this exercise is unnecessary . The programs, lesson units, and other related factors would be determined from the educational objectives of the real situation.

Program Requirements for a Local Environment. What follows is a description of the method used in this study to estimate the approximate number of unique programs which would have to be produced or acquired to perform a generalized educational assignment over a period of one year. The method is applied to grades 1 through 12 in two separate groups: grades 1 - 8 and grades 9 - 12.

For this illustration, it is assumed that general program material (enrichment, background material, general science, etc.) is acceptable for use over a four-grade span (average), e.g., 1 - 4, 3 - 6, 9 - 12. It is also assumed that specific subject-oriented material is acceptable for use in a single grade and only by a portion of the students within that grade; for example, Algebra I may only be applicable to algebra students in grade 9.

Grades 1 - 8

It is assumed that the students in grades 1 - 8 are all engaged in a single course of study, though this is not without exception. In some cases, course specialization may occur in grades 7 and 8; occasionally, elementary schools, especially private schools, may offer different courses. It is assumed that there are 900 hours in a school year.

180 days/year x 5 hours/day = 900 hours/year

It is assumed that 70% of the student's total time in school is available to receive media presentations. (This excludes lunch, study periods, etc.)

900 hours x 0.7 = 630 hours available for media presentation

It is assumed that media will be used an average of 10% of this time.

630 hours x 0.1 = 63 hours average media usage/student/year

It is assumed that 50% of the material presented applies to only a single grade.

63 hours/grade x 8 grades x 0.5 = 252 hours of material for single grade use

It is assumed that 50% of the material is applied to an average of four grades (some material may apply to eight grades).

63 hours/grade x $\frac{8}{4}$ x 0.5 = 63 hours of material for multigrade use

252 hours single grade materials
63 hours multigrade materials
315 hours of unique material for grades 1 - 8

Grades 9 - 12

It is assumed the students in grades 9 - 12 are engaged in one of three different courses of study. It is assumed that there are 1080 hours in a school year.

180 days x 6 hours/day = 1080 hours/year

It is assumed that 70% of students' total time in school is available to receive media presentation.

1080 hours x 0.7 = 756 hours available for media presentation

It is assumed that media will be used an average of 10% of this time.

756 hours x 0.1 = 75.6 hours average media usage/student/year

It is assumed that 20% of media material is used in all four grades and all three courses.

75.6 x $\frac{4}{4}$ x 0.2 = 15.1 hours or 15 hours for all grades and all courses

It is assumed that 80% of the material is used in a single grade.

75.6 x $\frac{4}{1}$ x 0.8 = 241.9 hours or 240 hours/of material.

Of this 240 hours, it is assumed that 1/6 is common to all three courses.

$240 \times \frac{1}{6}$ = 40 hours common to all three courses

240
-40
200 not common

200 hours x 3 courses = 600 hours to be used in one course and one grade

15 hours/allgrades/all courses
40 hours/grade/three courses
600 hours/grade/course
655 unique programming grades 9 - 12

Total unique programming

grades 1 - 8 = 315 hours
9 - 12 = 655 hours
= 970 hours or 1000 hours

It is assumed that each program is 20 minutes long.

1,000 hours x 3 program/hour = 3,000 unique programs to supply 10% average media coverage in a local district

Program Requirements for City Environment and Above. If 1,000 unique program hours are sufficient to accomplish the task assigned to a single school district, will the same number of hours be sufficient for all the school districts in a state?

The concept of unique programming hours used in this study does not directly take into account the actual subject material involved. This problem is handled by indicating an increase in material necessary to cover three different courses in a school. This method may be adequate to determine the average number of unique programming hours needed in a school or school district. However, just as an increase in hours was necessary to cover the three hypothetical courses in a local environment, a further increase in overall program hours may be necessary when the task is applied to a larger environment such as a state or region. The 1,000 hours may be adequate to supply each student (on an average) in a school or district with 10% media usage or availability. Due to overall curriculum differences, such as a larger number of subject offerings and differences in teaching methods, the 1,000 hours of unique programming may be insufficient toprovide 10% media coverage when applied to a large number of schools or school districts.

Taking this factor into account, the following number of hours of unique programming will be assigned to each area.

Local	1,000 hours
City	1,200 hours
Metropolitan area	1,300 hours
State	1,500 hours
Region	1,600 hours

Cost Structure

The stated task, to provide each student with material via some medium during an average of 10% of his total instructional time, offers a common source of data for the design of each media system. The definition of environments provides a method of examining systems as they are affected by an alteration in the size of the environment.

Classification by Function

Analysis for cost estimation can be further aided by classification of the elements of each media system as they relate to production, distribution, and reception.

Production. Production costs are those incurred in the inception, creation, development, and preparation of the instructional content. The acquisition of media programs and its related costs, such as selection and order handling, are also classified as production costs. For a media system, these costs must include the cost of curriculum design, the use and development of research and evaluation teams, media specialists, facilities, and all the myriad of inputs necessary to produce a successful learning experience for the student. Specific examples are script writing and recording of programs for radio and television, and writing computer programs for CAI.

Distribution. Distribution costs are those incurred in changing or copying the material from its original form, if necessary, and sending it to a point at which it will be reconverted to a usable form for the student. Usually, the transmitted material is not in a form which is immediately useful to the student. Examples are duplicating original tape and broadcasting for television, duplicating and mailing film from a processing center to a school, or duplicating and playing tape and transmitting to headphones in language laboratories.

Reception. Reception costs are those incurred in changing the form and presenting the distributed material so that it is useful to the student. Examples are antennas, TV sets, film projectors, screens, headphones, and carrels.

Classification as Capital or Operating Costs

Production, distribution, and reception costs can be classified as either capital (initial) costs or operating (annual) costs. Costs classified as capital costs include all purchases of goods and services that have a useful value of longer than a year or that are not incurred every year. The following items are considered as capital costs.

1. Initial planning. A breakdown of the planning effort and some estimates of man hours, travel costs, fees, etc., must be made for each system. The planning effort includes these activities.

   Survey of educational needs
   Definition of the problem
   Examination of possible solutions
   Design of systems
   Technical assistance and consultation
   Determining cost of alternative proposals

2. Initial training. In order to start a media system with a reasonable level of efficiency, a formal training program should be in operation prior to and during the installation of the system. Traditionally, problems of attitude have developed with the ultimate users when they were not properly informed, motivated, and trained. Training can be subdivided into three areas.

   Training of teachers, producers, and others who will actually produce the programs for the media

   Training of the technical operating and maintenance staff

   Training of classroom teachers to properly utilize the media

   The amount of training depends on the size of the system, intensity of usage, and the quality of performance which will be acceptable. Historically, it has depended upon the time and money that are available for this purpose.

3. Facilities. When an entire room, group of rooms, or separate building (such as a TV studio or film library) is required for a media function, it will be costed as new construction on a square foot basis and provision for future expansion is assumed.

When a very small area of an existing facility (such as space taken by TV set in classroom) is used, these costs will be ignored.

4. Initial equipment and programs. Included in this category are the costs of equipment (including test equipment) that must be purchased and program materials that must be produced or acquired to implement the system.

Costs classified as operating costs include all purchases of goods and services that have a useful value of less than a year or that are incurred every year. The following items are considered as operating costs.

1. Operation of equipment. Costs related to the operation of equipment are divided into these categories.

   Salaries of operating personnel (professional and/or technical)

   Annual cost of heating, air-conditioning, lighting, other utilities, etc.

   Consumable supplies

2. Maintenance of equipment and facilities. Most maintenance costs are calculated as a percentage of initial equipment cost. Equipment maintenance will usually average about 10% of purchase price and includes such items as replacement of spare parts, replacement of test equipment and tools, and some portion of building maintenance cost where applicable.

3. Training. A continuous training program is necessary due to changes in personnel, methods, and equipment. Costs must be estimated for activities usually associated with continuing training programs.

4. Administration. Administrative costs vary with size and usage of the media system. Total costs of salaries increase at a somewhat linear rate as the system increases in size. Communication costs such as travel, telephone charges, and mail tend to expand

rapidly as the size of the system, its complexities, and area of coverage increase.

5. Related materials. The operation of any media system requires the use of printed material to provide directions, schedules of events, guidelines, lesson plans, etc. The cost of this material is closely related to the number of hours of unique programming and the total number of users in the system (teachers and students). A cost for each unique hour of programming can be assigned and then extrapolated over a number of users as the system size increases from school district to state or region.

6. Current programming. This category covers the expenditures necessary to produce material other than those related to revision and modification of instructional programs. Included are announcements of school or community activities and materials for meetings, conferences, and special instructional projects.

7. Research, Testing and Evaluation, and Program Updating. A cost must be assigned to measuring and evaluating the operation of each media system. There must be an evaluative feedback within the system in order to properly operate and improve the system. Testing and restructuring the materials is one part of this process.

   This cost varies with student population, number of subjects offered, and intensity of media usage.

   Some of the costs will arise from the following activities.

   Test development and research
   Testing
   Evaluating
   Revision of materials

   The cost of actually remaking the program materials, as indicated by the research, is included in the programming cost, since this cost is incurred on the average of every five years.

Equivalent Annual Cost

To simplify cost comparisons, the capital costs can be amortized over the life of the investment and added with interest to the average annual operating cost to form an equivalent annual cost. The result is a uniform yearly figure which includes amortization and interest. These costs can be examined for each environment to determine cost trends as they relate to student population, area serviced, etc. To calculate the equivalent annual cost, first a capital recovery factor (c. r. f.) is obtained from standard financial tables for a particular interest rate and life of the purchase. For example, the c. r. f. for five years and 1% interest is a little over 20%. The capital cost is multiplied by the c. r. f. and the product is added to the annual operating cost to obtain the equivalent annual cost.

Cost Structure Model

A cost structure can be established which encompasses the capital and operating costs for production, distribution, and reception for each system in each environment. This cost structure is illustrated in Figure 1.

Cube "A" illustrates an area of costs which is associated with the operating expenses during the production (acquisition) of educational materials to be used by a media system in a metropolitan school environment. Cube "B" is symbolic of operating costs for distributing instructional materials within a local school district.

Sources and Use of Cost Data

The collection of cost data pertaining to an element of a media system usually resulted in a range of costs, not a precise value. The costs were collected from the following sources: equipment catalogs, telephone conversations, reports (both objective and subjective), private conversations, and personal experiences.

The sources of cost data are indicated in most cases; however, there are some instances where the source is not mentioned. These data costs are derived from the experience and personal investigation of the project participants. In those cases where the numbers presented need to be qualified, the type of interpretation which should be placed on their value is indicated.

To estimate total costs for the systems investigated, a single value for each item was selected from the range of costs collected. The choice was usually based on intuitive feeling of appropriateness for the environment. In most cases, the value selected might be the mode of the frequency distribution of selections by purchasing agents under the given conditions. The assumptions which were made to derive the estimated costs are included in the report as the need arises.

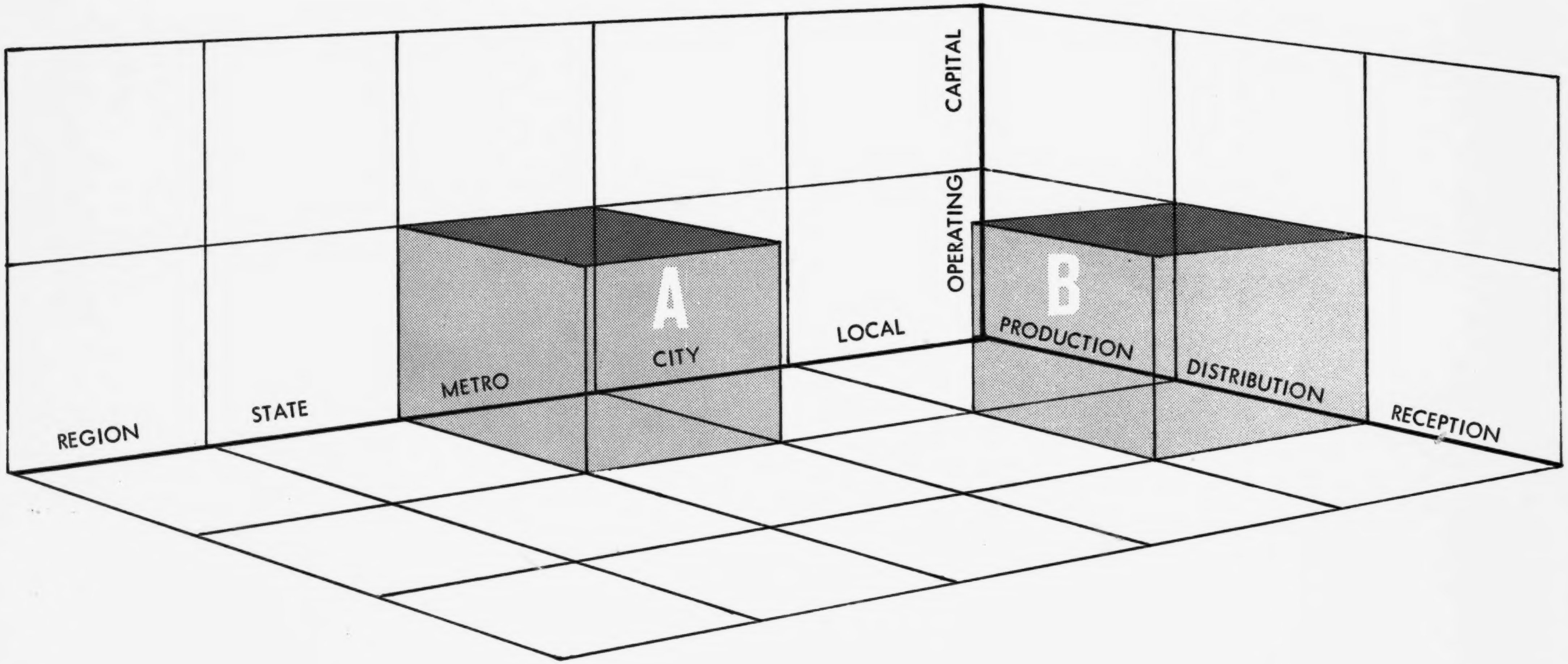

CAPITAL
OPERATING
REGION
STATE
METRO
CITY
LOCAL
PRODUCTION
DISTRIBUTION
RECEPTION
A
B

Figure 1. Cost Structure Model

The actual dollar cost per system may not be directly applicable to a specific educator's unique problem; however, it can indicate general cost trends. The value of this cost structure lies in the generality of its approach. The variables of a real situation can be applied to the structure to provide more realistic comparisons for an actual situation. The cost structure might be looked upon as a tool which can be applied along with measures of "media effectiveness" to solve "real world" problems.

COST ESTIMATES

Costs were estimated for each of the media systems investigated using the basic model discussed in the previous section. The detailed cost data are presented in Section A of the Appendix.

The following graphical illustrations have been prepared from the cost data. There are two major sets of graphs presented and discussed. Each graph in the first set presents the production, distribution, and reception costs for one instructional media system. A second set of illustrations presents graphical comparisons of the costs of media systems. Production, distribution, reception, and total costs are shown individually.

Cost of Each Media System

Each of the following graphs presents the production, distribution, and reception equivalent annual cost per student, i. e., annual operating cost plus amortization with interest. The cost per student is shown over the range of environments. The environments are listed across the bottom of the graph. Each of the five environments has a given number of students and the costs have been estimated only at these five points. Some media are not appropriate for some environments, and an N/A (not applicable) is shown.

Television Production Cost

Figure 2 presents the equivalent annual production costs, operating plus amortization, used for each television system. The production of instructional television materials can be treated independently of distribution and reception, and it is, therefore, presented and discussed before the individual television systems are presented. Three different costs for production of materials are shown.

Minimum Production Cost. This is the minimum estimated cost of producing usable instructional television material. It is based on a $300 per hour basic production cost and a rental cost of $145 per hour plus associated costs of administration, related materials, and research and evaluation. Complete figures and rationale are shown in the Appendix.

High Quality Production Cost. This is an estimate of the costs of advanced state-of-the-art production based on $5,000 per hour production cost and rental at $145 per hour plus associated costs of administration, related materials, and research and evaluation.

National Programming Source Costs. This cost assumes that a national center provided copies of materials at a figure approaching the duplication cost of $1 per minute. No such center now exists nor is there a broad range of original instructional material available.

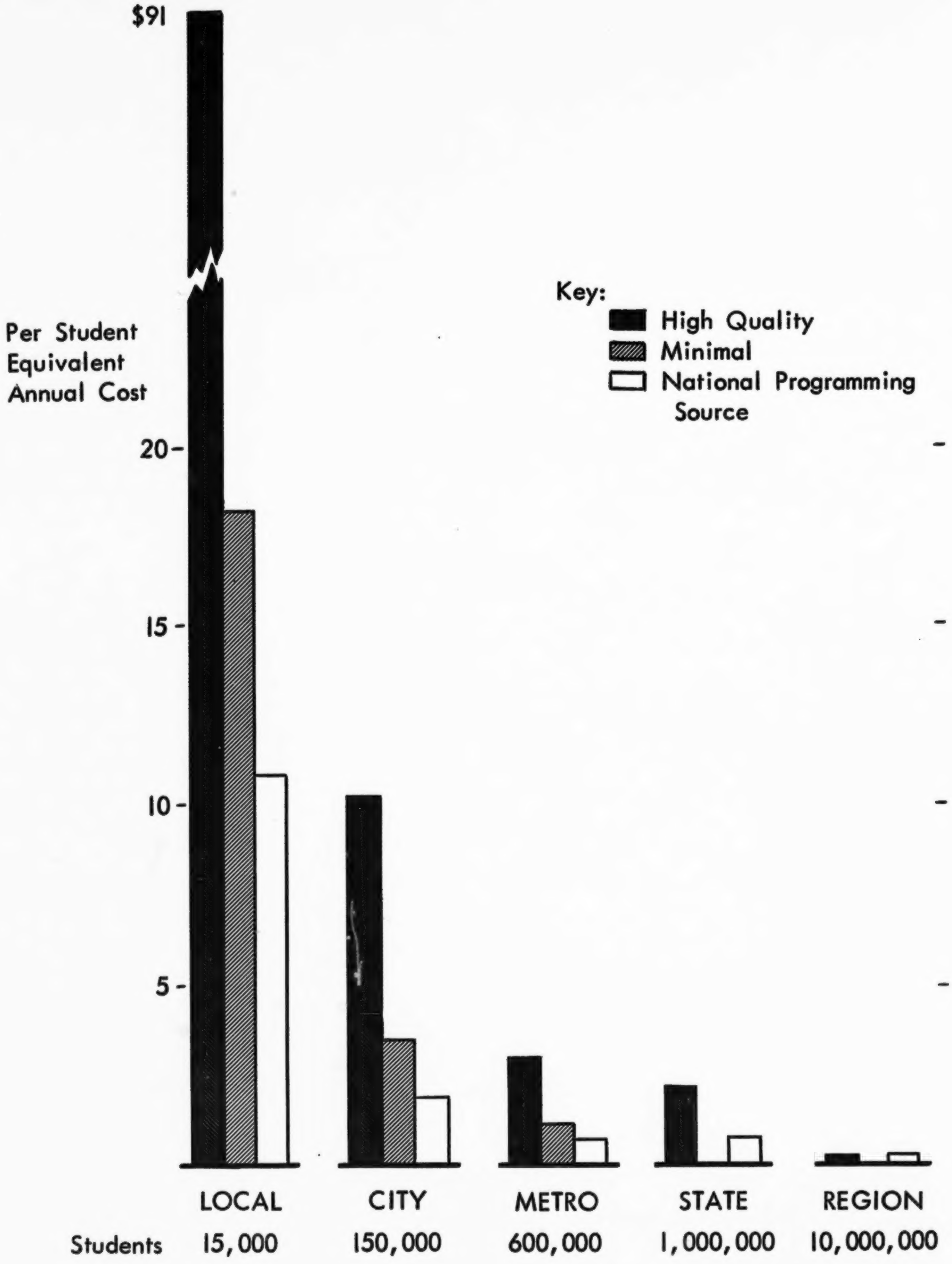


Figure 2. TV Production Costs

The number of hours of programming in the model increases from 1,000 at the local level to 1,600 at the regional level.

The costs shown in Figure 2 indicate that the cost of high quality production is $91 per student, which is certainly beyond the funding ability of a local school system of 15,000 students. The same type of programming would be about $10 per student for the city of 150,000 students, which is still a large figure. Therefore, the minimum programming costs were used in the model for the local and city school systems. Although it would be desirable to offer the high quality materials in these schools, no school systems are presently able to do so. If an estimate of the cost is desired, the reader can substitute either the high quality or the national programming source costs shown in the tables of total production cost in the Appendix.

The most important observation concerning production costs per student is that the cost decreases rapidly as the number of students increases. This behavior is typical of a fixed cost. The costs in the production category of the model are mostly those of producing the television programs. This programming cost has two variables, price and quantity. Quantity increases as larger areas are served. The increase in program hours is necessary because a wider range of students is encompassed by the larger system. An increase from 1,000 hours for the local environment to 1,600 hours for the regional environment was assumed in the model. Unfortunately, it is very difficult to estimate how large the increase should be. Even if it were 300%, the production cost for the largest system would be less than a dollar per student per year. The price of materials for the larger environments has not be increased directly, but the percentage of rented materials was decreased slightly. Fewer rentals means increased costs because rental is less expensive. In practice, the amount spent per program does seem to increase with the size of the area served in contrast to the constant cost per hour assumed here. This is mostly a budgetary effect. Larger schools have more money, but since their programming is almost always below the "high quality" level, they spend more per program whenever funds are available. Since high quality production is provided in the model, no such increase is needed here.

Looking at the annual production costs per student, it is encouraging to find that high quality materials can be produced for under $11 per student for all areas of city size or greater. If minimum programming is acceptable, even school systems of 15,000 can produce materials for under $20 per student per year. There is at least one system in the U. S., the Washington County, Maryland system, which is spending that much for programming. Finally, if a national center for copying a large supply of good materials were available, the programming cost would be about $10 per student for the local school and would decrease to only a few dollars for larger areas.

The production cost figure points to the need of school systems to cooperate in obtaining instructional television materials. It appears that any one school system will have great difficulty in financing its own production at any but a minimal level. Schools should join together in a cooperative production effort. It seems strange that no sizeable amount of cooperation in producing materials for physically separate distribution systems has taken place. The most obvious reason that cooperation has not been practiced is that each system has different problems and its materials reflect those problems. On the other hand, thousands of school systems use the same textbooks.

Four-Channel Airborne Television

Figure 3 presents the costs for the four-channel airborne television system. The airborne system is applicable only to the state or regional levels because each station can cover a very large area. Production costs decrease from over $2 to about $ .25 per student per year from the state to the region.

Distribution cost is about $2 per student per year for the region and $3 per student per year for the state.

Reception cost is approximately $6 per student per year, of which about $2. 50 is for teacher training.

Total cost is about $11 per student per year at the state level and about $8 for the region.

Four-Channel ITFS and New Higher-Powered ITFS

Figure 4 presents the cost for the ITFS television system. Production cost decreases from about $18 to about $ .25 per student per year over the range of environments. There is a slowdown in the decrease for the city to metropolitan range because of the assumed switch from "minimum" to "high" quality production.

The distribution cost decreases from almost $6 for local systems to about $ .50 per student per year for the metropolitan area. It then increases to about $1 per student at the state and regional levels because of a decrease in the number of students per square mile.

The reception cost is about $7 at the local level and decreases to about $6 at the regional level. About $2. 50 of this cost is for teacher training.

The total cost is $31 per student, which is quite high at the local level, but decreases to between $11 and $9 for all of the other environments examined.

The cost figures for the ITFS system for state and regional service are based on a higher-powered transmitter than is now permitted by FCC rules and are, therefore, somewhat tenuous.

Four-Channel 1973 Satellite

Figure 5 presents the costs for the four-channel 1973 satellite system. The satellite system proposed for direct telecast to schools could probably be instituted

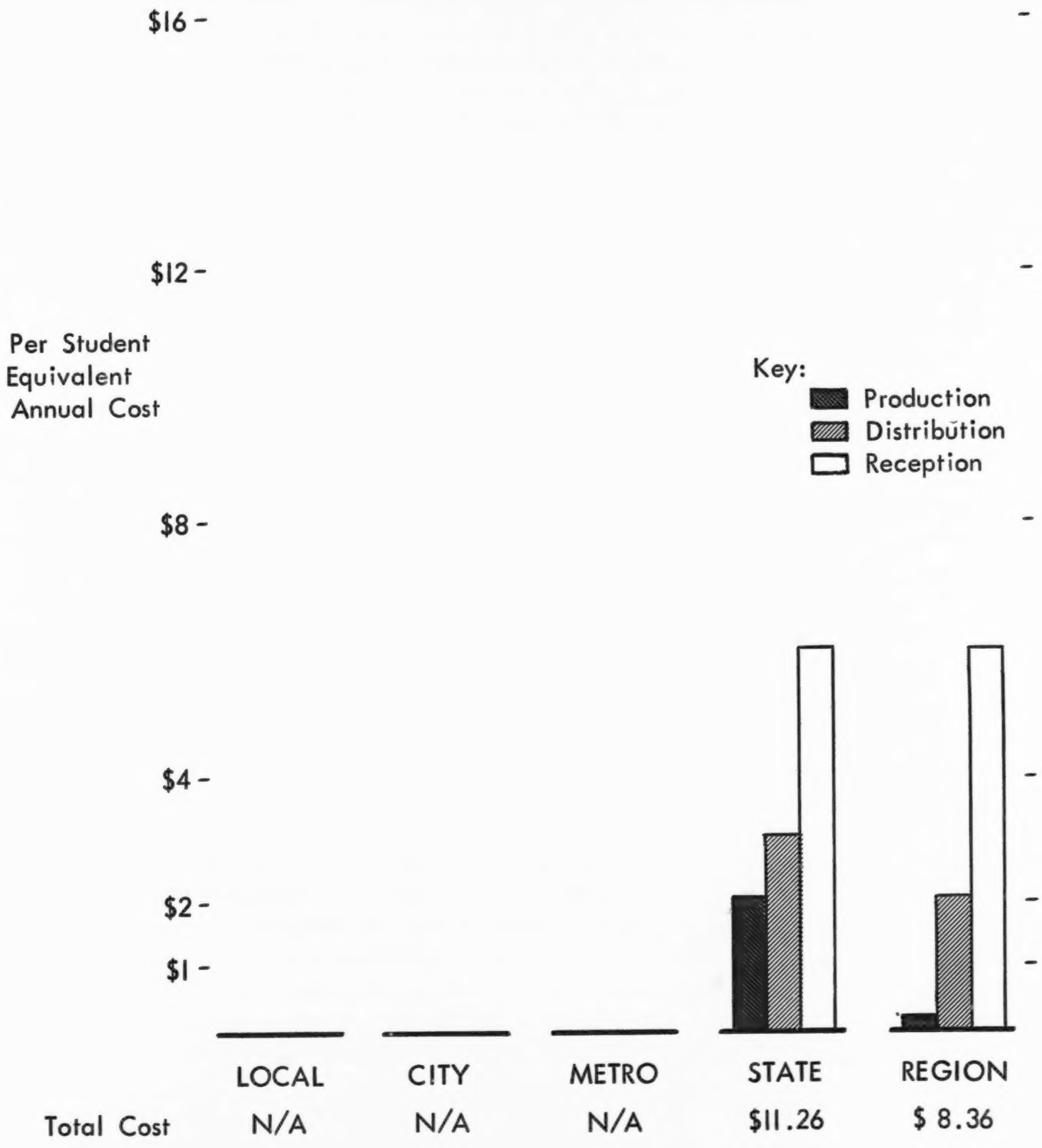


Figure 3. Per Student Equivalent Annual Cost - Airborne TV

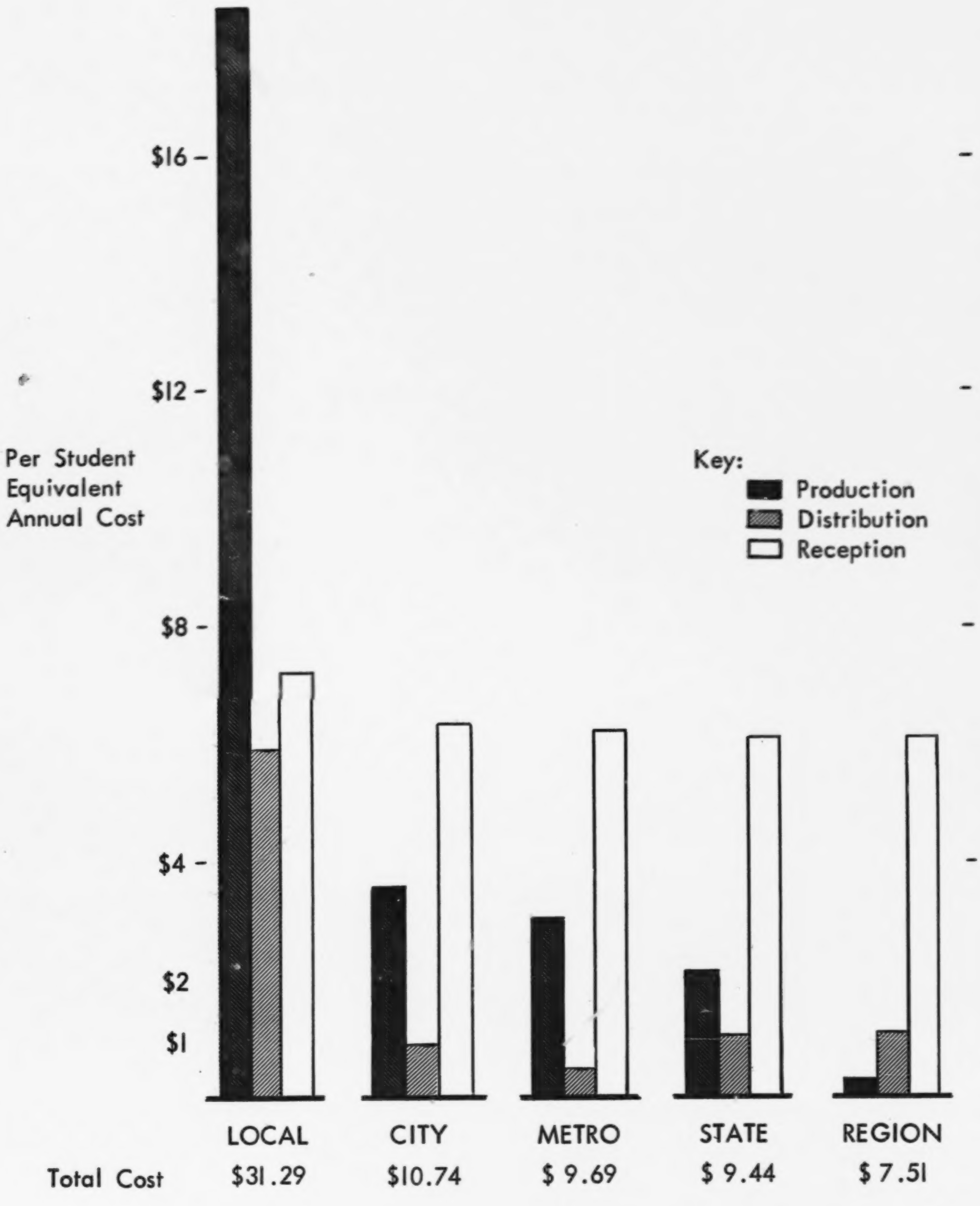


Figure 4. Per Student Equivalent Annual Cost - ITFS

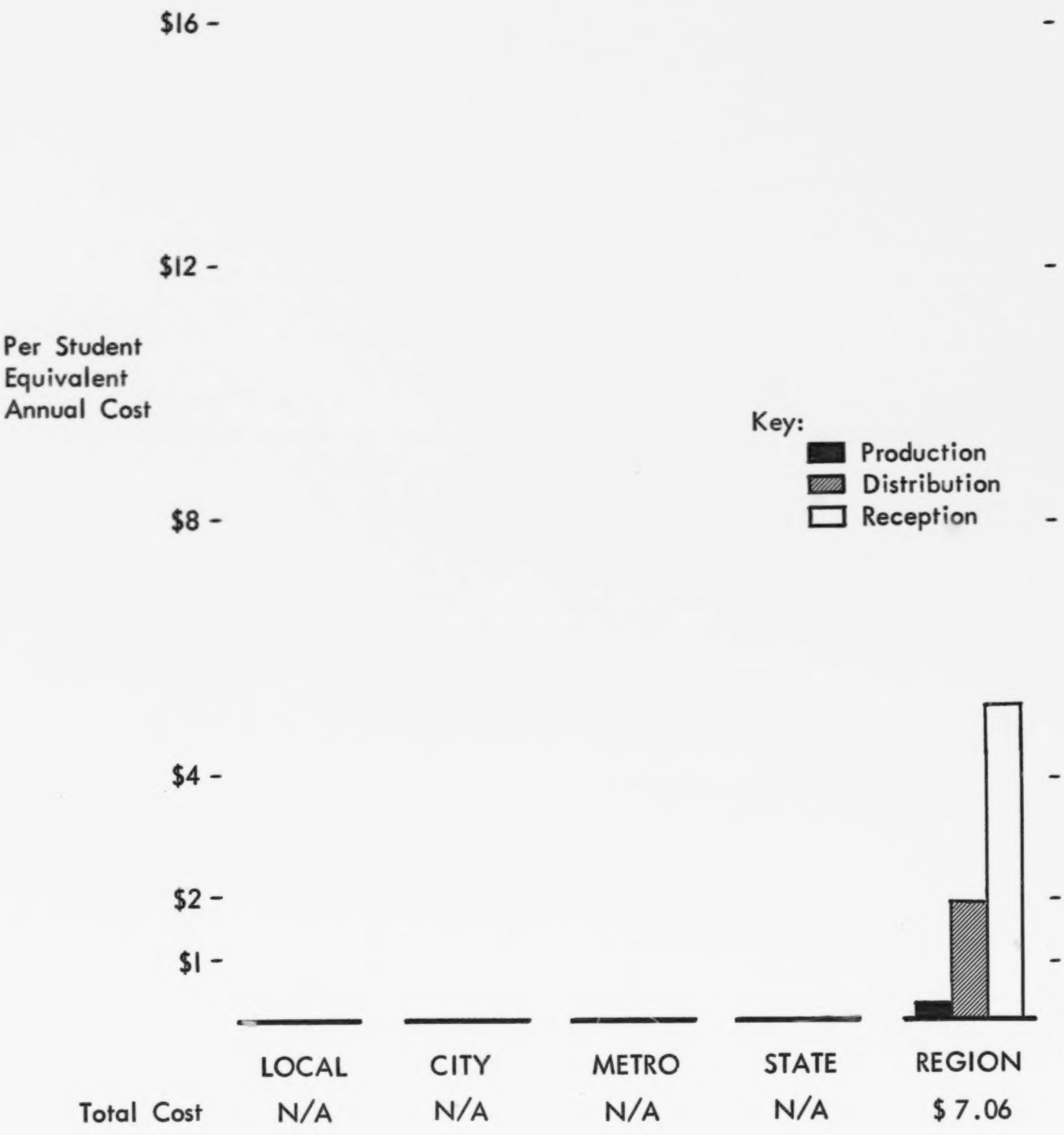


Figure 5. Per Student Equivalent Annual Cost - Satellite TV

in the mid 1970's. The costs assume substantial technological progress in the interim. The satellite system would be applicable only to the regional environment.

The production cost is $ .24 per student per year.

The distribution cost is less than $2 per student per year, and would increase inversely with population density.

The reception cost is $5 per student per year of which about $2.50 is for teacher training.

The total cost is around $7 per student per year for a region of 10,000,000 students.

Four-Channel UHF Television Broadcasting

Figure 6 presents the costs for the four-channel UHF broadcasting system. Production cost decreases from about $18 to about $ .25 per student per year over the range of environments. There is a slowdown in the decrease for the city to metropolitan range because of the assumed switch from "minimum" to "high" quality production.

Distribution cost decreases from $17 at the local level to about $ .70 per student per year at the metropolitan level, but then increases to over $4 for the state and region because of a decrease in the number of students per square mile.

The reception cost is about constant, ranging from about $6.50 to just under $5.30 per student per year.

The total costs of $42 are quite high for the local area since both production and distribution are costly for the 15,000 students assumed to be in the local system. Note that the cost decreases rapidly so that for 50,000 students in one system the total annual cost would be only about $25 per student. The total costs for the city, metropolitan, state, and regional systems are around $10 per student per year.

Four-Channel Closed-Circuit Television

Figure 7 presents the costs for the four-channel closed-circuit television system. Production cost decreases from about $18 to about $ .25 per student per year over the range of environments. There is a slowdown in the decrease for the city to metropolitan range because of the assumed switch from "minimum" to "high" quality production.

The distribution cost decreases from about $9 at the local level to about $2 per student per year at the city and metropolitan areas. The cost increases to around $6 for the state and region because there are fewer students per square mile.

The reception cost ranges from $6 at the local level down to about $5 per student per year at the regional level. About $2.50 of this cost is for teacher training.

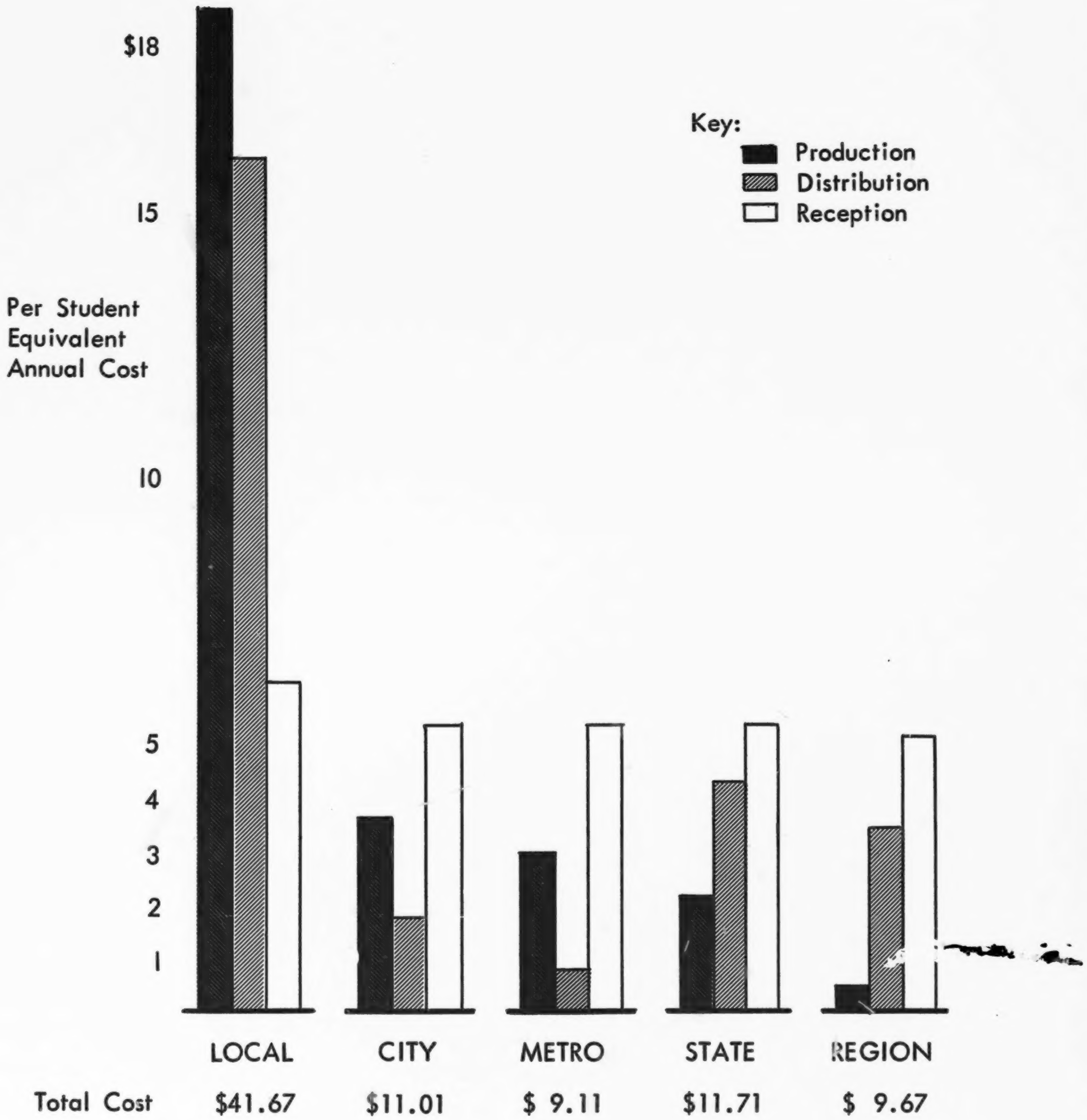


Figure 6. Per Student Equivalent Annual Cost - Four-Channel UHF TV

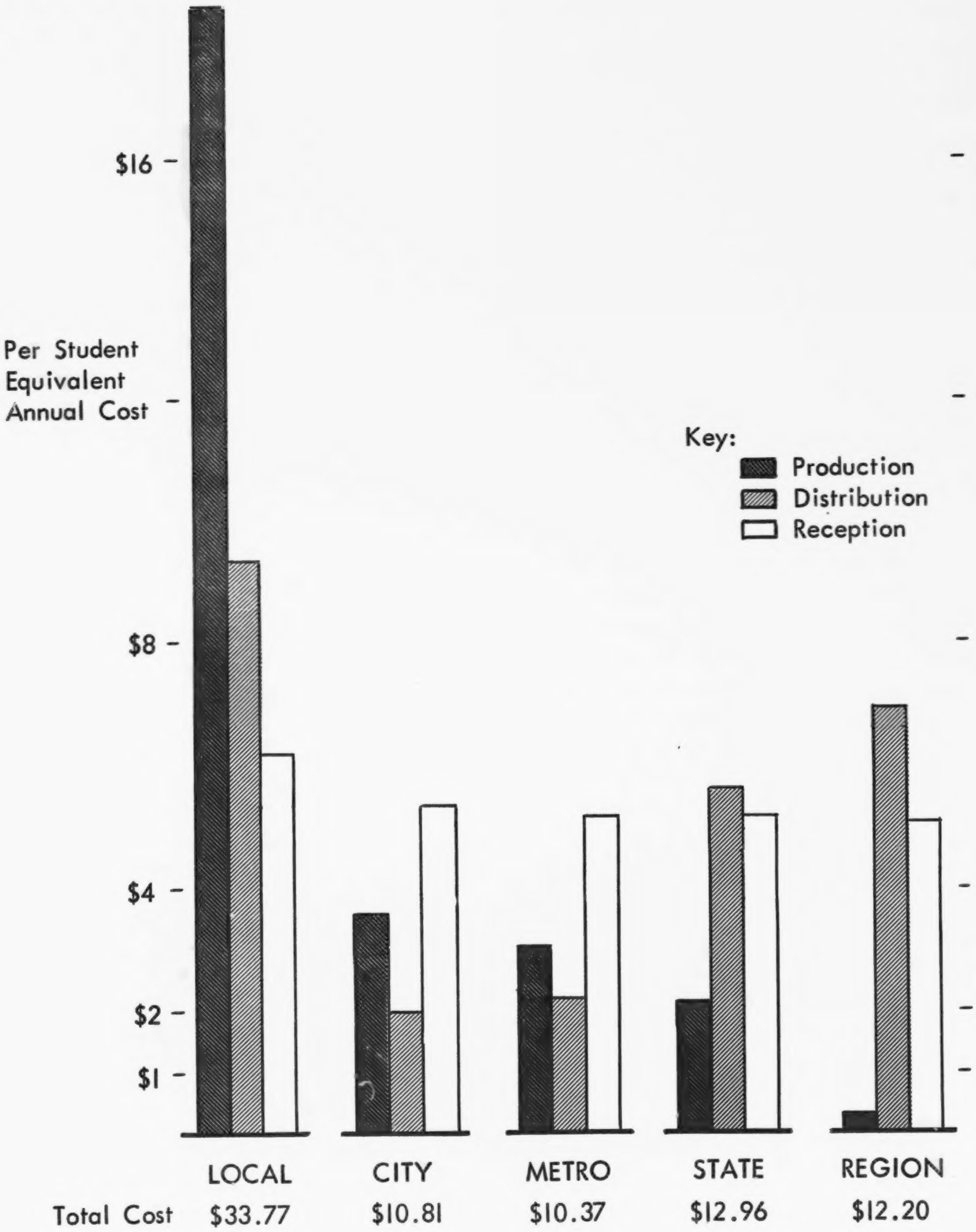


Figure 7. Per Student Equivalent Annual Cost - Closed-Circuit TV

The total cost is quite high for the local system, about $34 per student per year, but decreases to between $10 and $13 per student for the larger areas examined.

Video Tape Recorder Network

Figure 8 presents the costs for the video tape recorder (VTR) network. Note that the cost axis increases twice as fast as for the other television systems. Although the costs of the VTR network were only estimated for the local level, the following projections were made.

The distribution cost would be about $40 per student per year at all environment levels. Since this system requires a library and tape recorders in each school, the cost per student would not decrease for the larger areas.

The reception cost would range from $6 at the local level down to about $4. 50 at the regional level. About $2. 50 of this amount is for teacher training.

The total cost would be quite high, ranging from $64 at the local level to $44 per student per year at the regional level.

16MM Film Systems

Figure 9 represents the results for the 16mm film system. Note that the cost axis increases twice as fast as it does for the television.

The 16mm film system provides for distribution from a central audiovisual center. It would probably not be feasible to distribute materials from a regional center and, therefore, no regional costs are given. The production cost ranges from about $37 to $46 per student per year. Production costs do not decrease, since film prints are purchased at the same price for each school. The increase in cost results from the increase in the number of programming hours from 1,000 at the local level to 1,600 at the regional level.

The distribution cost ranges from $6 per student per year for the local area down to about $3. 50 at the metropolitan level. It then increases to about $4.75 at the state level.

The reception cost decreases from about $9 at the local level to about $8 per student at the state level. About $2. 50 of this amount is for teacher training.

The total costs range from $50 to $59 per student per year.

Four-Channel Multiplex Radio

Figure 10 shows the costs for the four-channel multiplex radio system.

The production cost is based on an improvement over present production quality. The cost ranges from about $3.70 per student per year at the local level down to considerably less than one dollar for the larger areas. There is an increase in production costs from the city to the metropolitan level because of the assumed switch from "minimum" to "high" quality production.

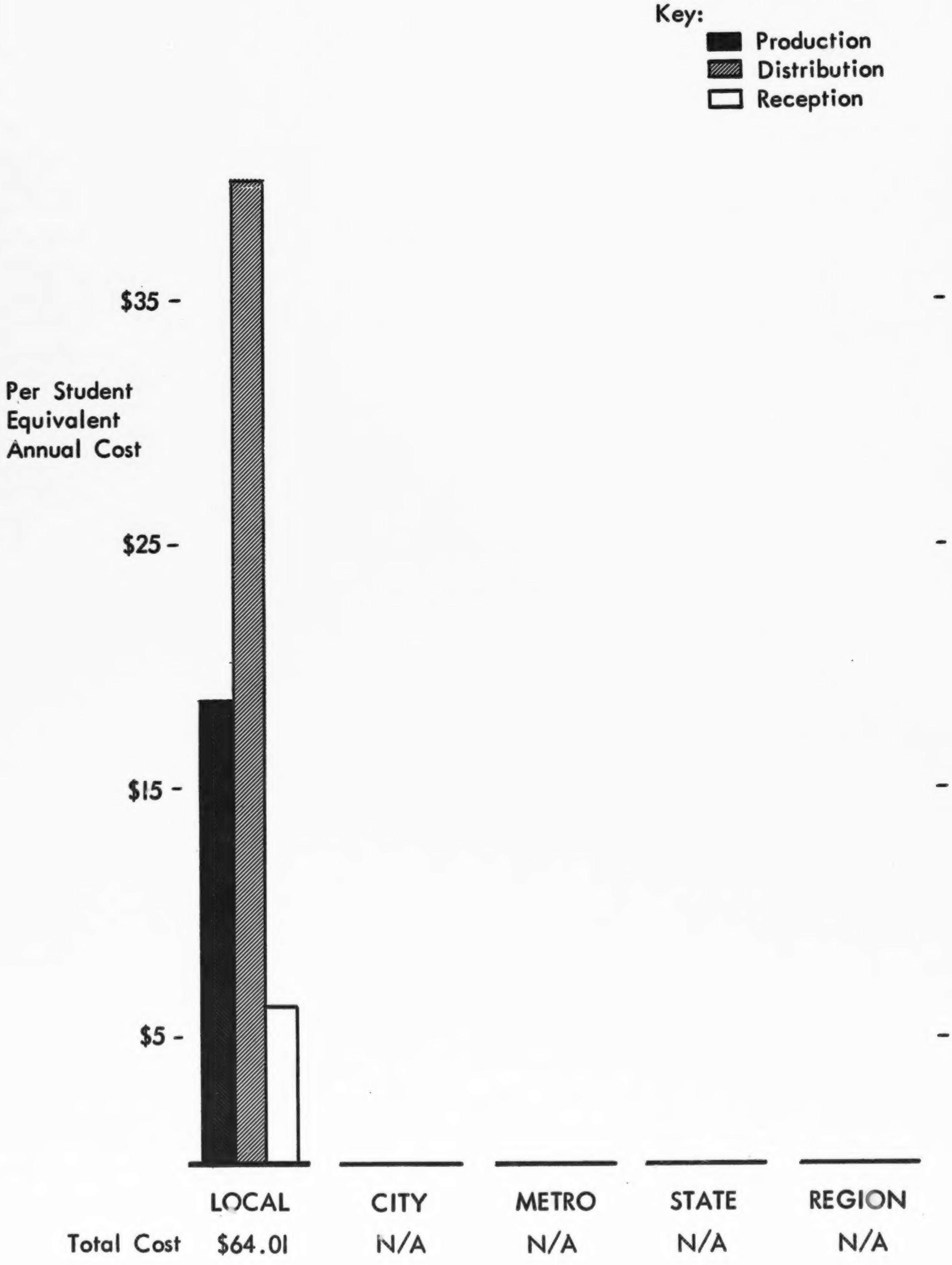


Figure 8. Per Student Equivalent Annual Cost - VTR

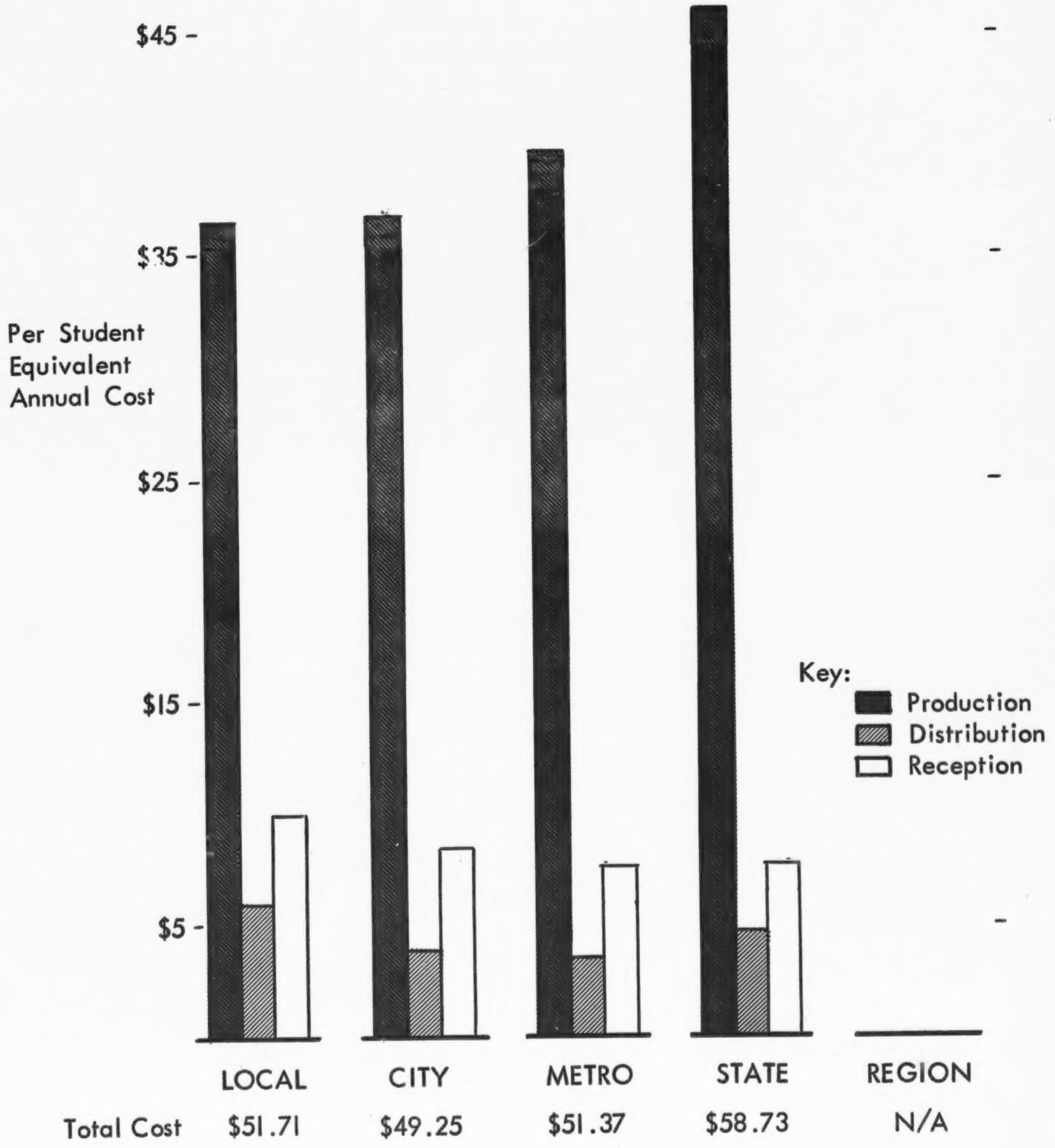


Figure 9. Per Student Equivalent Annual Cost - 16MM Film

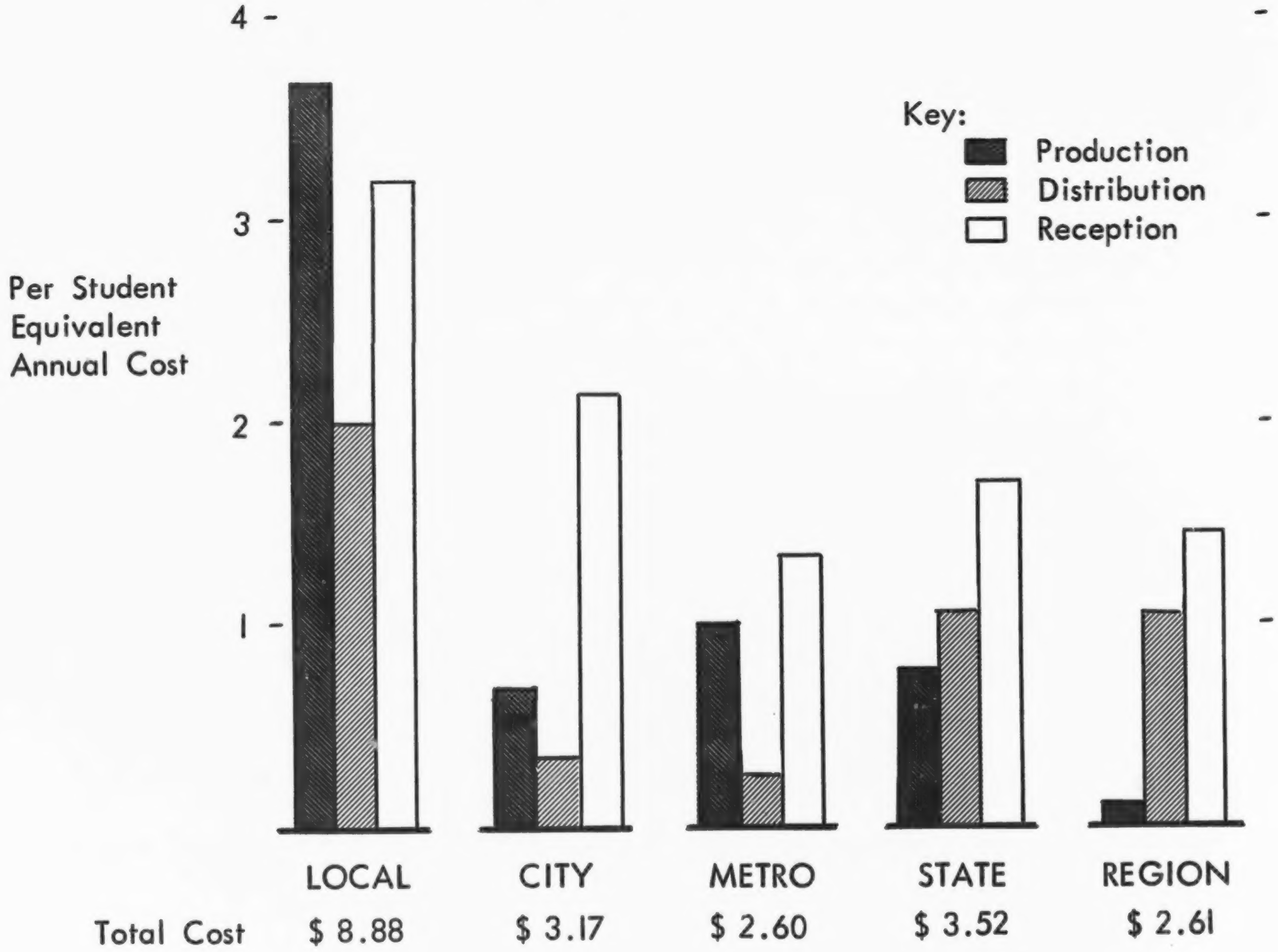


Figure 10. Per Student Equivalent Annual Cost - Four-Channel Radio

The distribution cost decreases from about $2 per student per year at the local level to about $ .25 at the metropolitan area. It then increases to about $1 per student per year for the state and regional areas because of decreased population density.

The reception cost ranges from slightly over $3 at the local level to about $1.50 at the metropolitan, state, and regional levels.

The total cost ranges from about $9 per student per year at the local level to around $2.50 to $3.50 for the larger areas.

Language Learning Laboratories

Figure 11 indicates the per student equivalent annual cost for learning laboratories at the local and city levels.

The production cost is over $2 for the local school system and decreases to a little over $1 per student per year for the city because of the increased number of students served.

The distribution cost is almost $1 per student per year for the local level and is approximately $ .50 per student for the city.

The reception cost is about $3.50 per student per year with some reduction for the larger area.

The total cost is around $6.50 for the local system and approximately 2/3 of that amount or around $4.50 per student per year for the city system. The principal reason for the decrease is the savings in manpower required to plan, administer, and operate the city system. Whereas 10 times the equipment and students are encountered at the city level, the personnel costs associated with the media system increase only threefold.

Larger systems were not explored because the administrative savings and the savings from the utilization of the materials by a larger number of students would not continue. The administrative structure of a metropolitan, state or regional system would be much larger with little decrease in cost per student. Again, as the level of application increases, the duplication and distribution costs for materials become higher than the costs of purchasing commercially available language tapes.

Dial Access Systems

Figure 12 shows the equivalent annual per student cost for dial access systems for local, city, and metropolitan areas.

The system provides the teacher with the ability to choose from a large number of audio selections for the classroom from a central service.

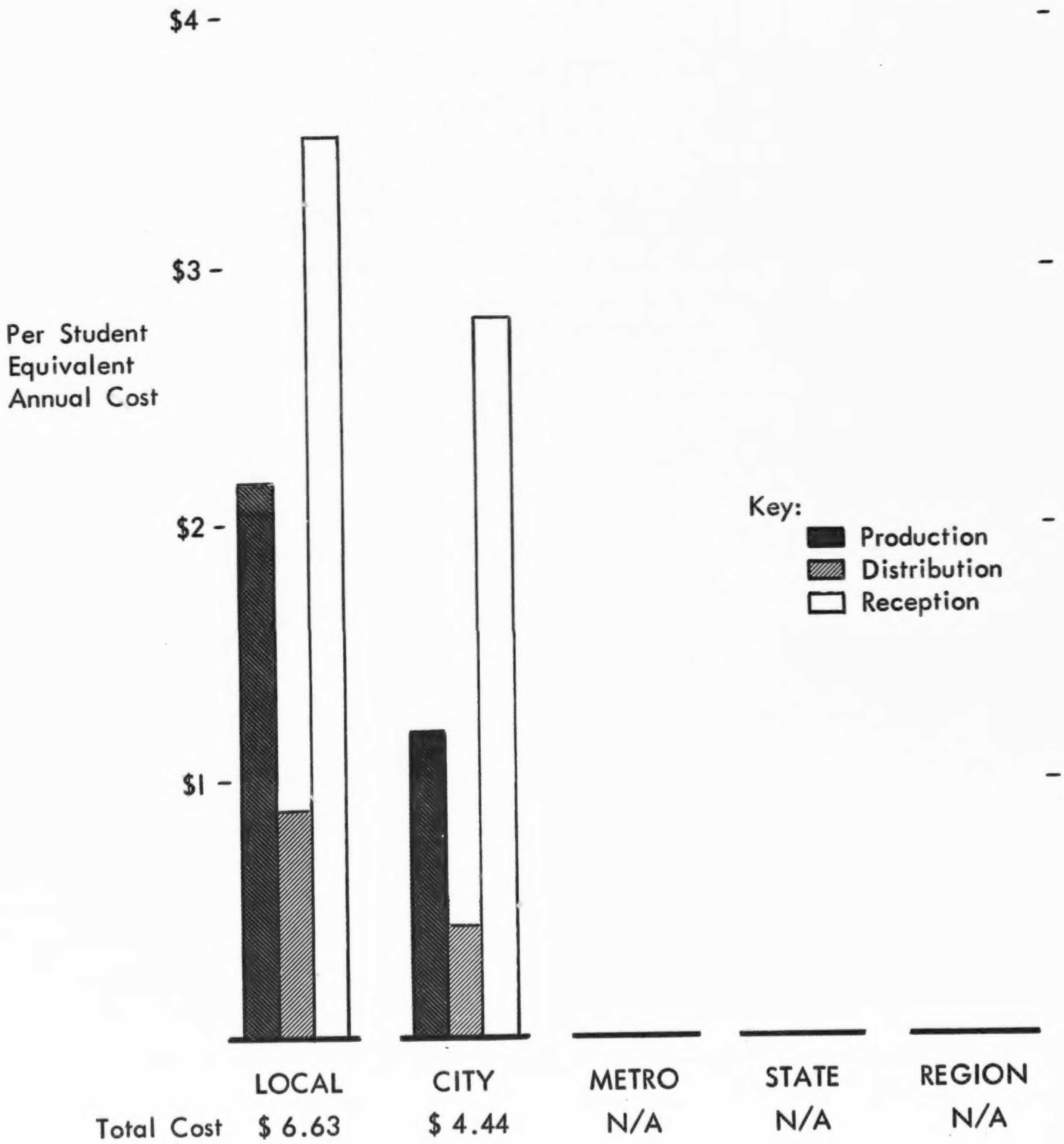


Figure II. Per Student Equivalent Annual Cost - Language Lab

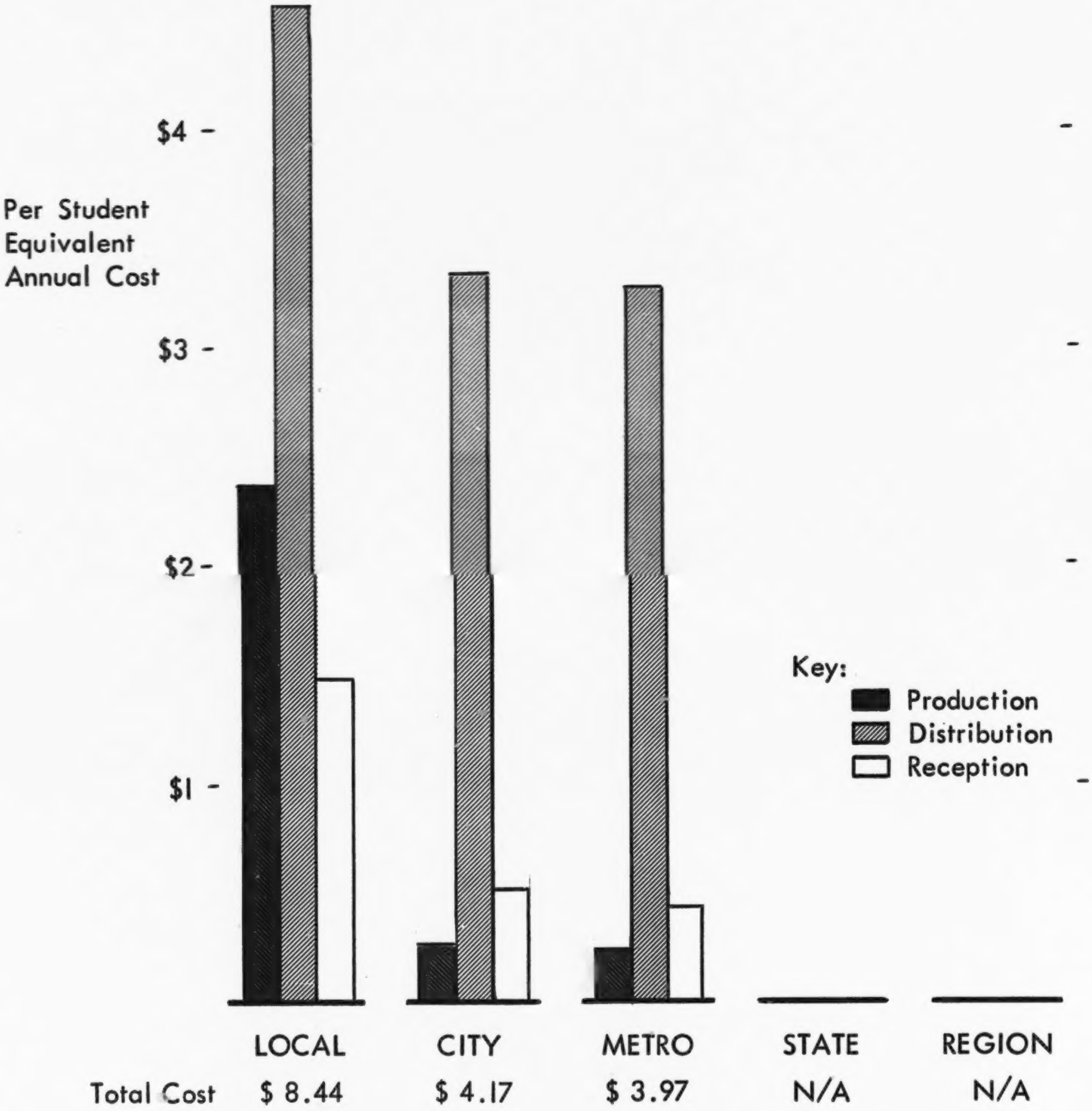


Figure 12. Per Student Equivalent Annual Cost - Dial Access

The production cost is over $2 per student per year for the local level and decreases to about $ .25 for the larger areas. The reduction in cost is, in part, the result of the location of the production facility. It is easily accessible to the average teacher at the local level, but in the city and metropolitan environments, the central facility becomes more difficult to use.

The distribution cost is about $4.50 per student per year for the local level and decreases to less than $3.50 for the city and metropolitan areas.

Distribution costs decrease from the local level to the city level because the density of schools per square mile increases. This results in lower communications line costs.

The reception cost is approximately $1.50 per student per year for the local level and decreases to about $ .50 for the city and metropolitan areas. Reception costs decrease because it is assumed that initial personnel and overall operating and maintenance costs will not rise in direct proportion to the number of receiving stations.

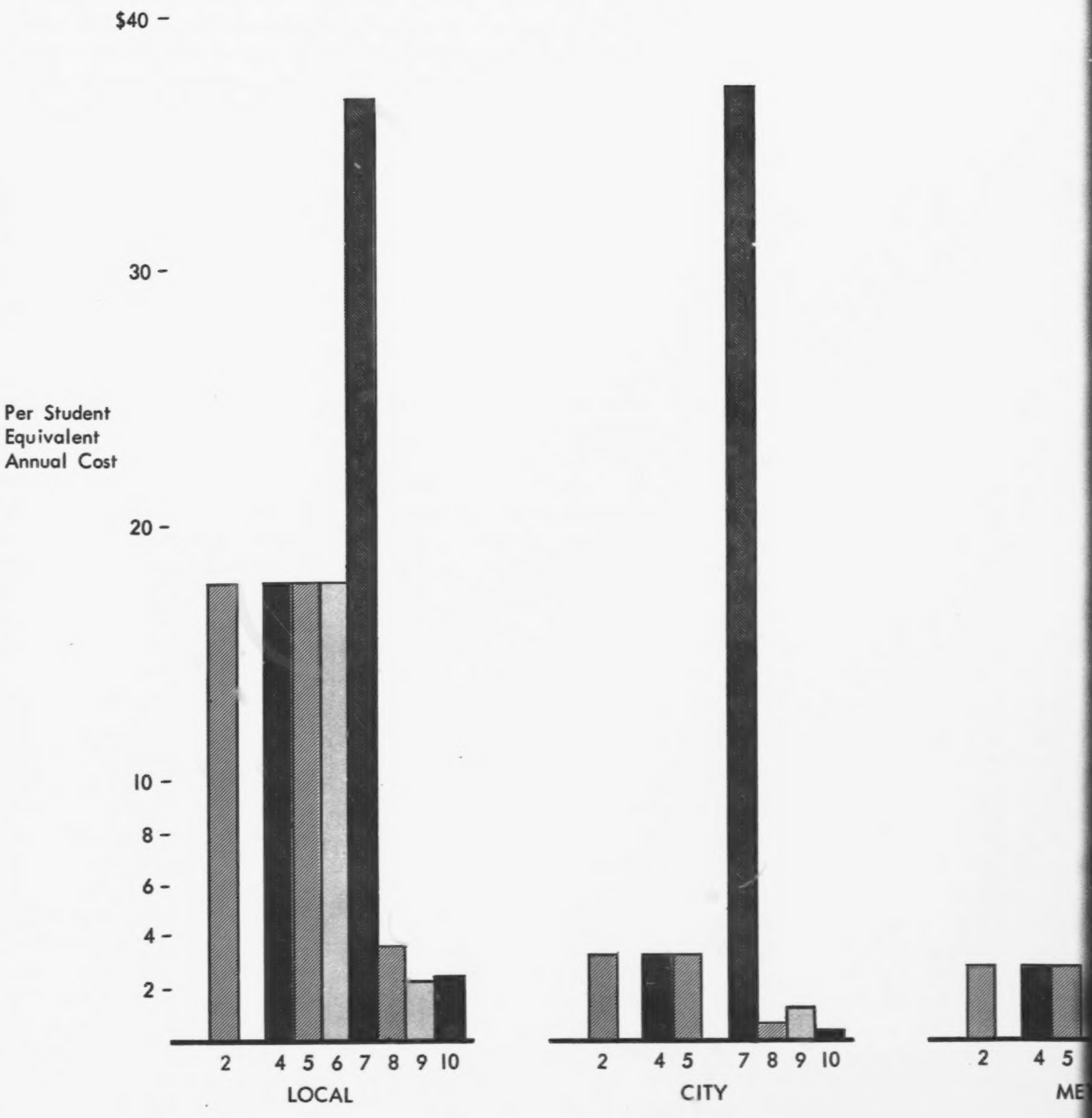
The total cost is about $8.50 for the local system and approximately $4 for the city and metropolitan areas. Since the cost of communications lines increases with a lower density of schools, distribution costs increase rapidly at the state and regional levels. Therefore, systems for larger areas were not investigated.

Comparison of Costs

The second set of graphs illustrates the equivalent annual cost per student of the production, distribution, reception, and total cost categories for all media. These graphs are used in discussing the cost comparisons of the media systems.

Production Costs

Figure 13 shows annual equivalent production cost for each media. The cost for production of television and film per student per year is quite high, but the production cost for television decreases rapidly from $18 to $.25 as the number of students is increased. Recall that the programming is the major portion of production cost. At the local and city levels, low-cost programming for television was chosen for the model while high quality programming was specified for the larger areas. In contrast, because of present film print pricing practices, the film cost for production does not decrease with higher numbers of students. It increases from $37 to $46 per student per year. The increase reflects the increase in the number of programming hours from 1,000 at the local level to 1,600 at the region. The present pricing practices do not reflect the large increase in volume which is incorporated in the model, and might well change if an increased volume of prints was assured. Nor do the present pricing policies take into account the possibility of producing coordinated series of lessons with a simpler instructional television format. These would probably cost considerably less per lesson. On the other hand, to change these practices would lead to the abandonment of one of the peculiar advantages of film, i. e., the ready availability of a wide range of materials of high technical quality.


$40
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Per Student Equivalent Annual Cost
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CITY
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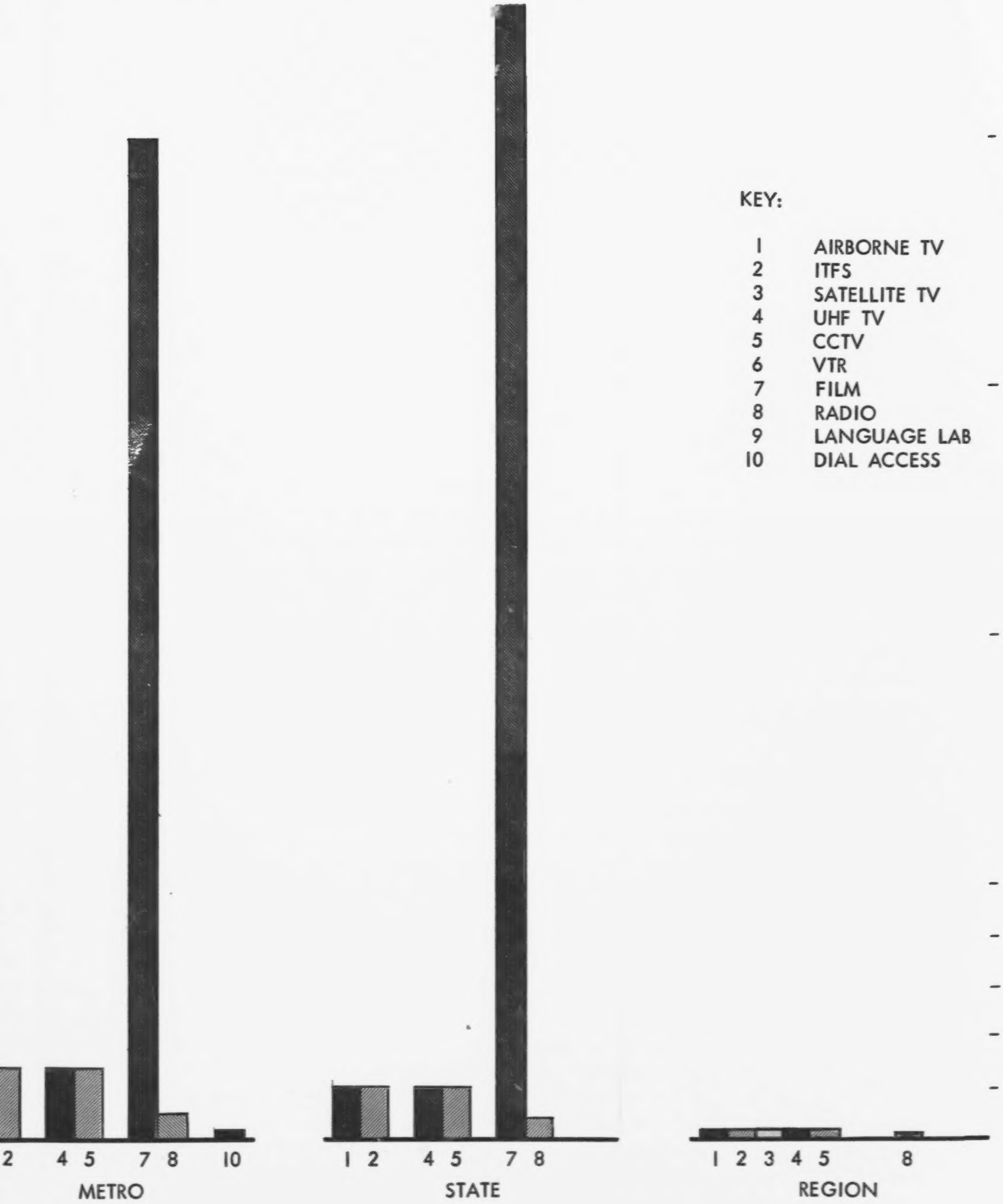


Figure 13. Production Cost Comparison

The costs for radio production are somewhat high, about $4 at the local level, but decrease rapidly with larger numbers of students. The cost for the metropolitan and other areas is approximately $1 and less. The costs are based on rates higher than the present cost of obtaining duplicates from the Educational Audio Network. The increased rate provides funds for producing new series of instructional materials. The radio production costs also include costs for noninstructional broadcasting of about $1 per 100 persons in the broadcasting area. The radio production costs are much lower than the television production costs.

The production cost for language learning laboratories, around $2 per student per year, is not strictly comparable to the production cost for the other systems. The language laboratories can occupy 10% of the student's time without 1,000 hours of unique programming which is the amount of programming assumed for other media at the local level. Nor is it at all obvious that the student should spend 10% of his time using a language laboratory. Therefore, a figure of 225 hours of unique programming has been used in the model. The elementary schools are assumed to use a passive or listening-only system. Only a small amount of money has been made available for programming for the elementary schools.

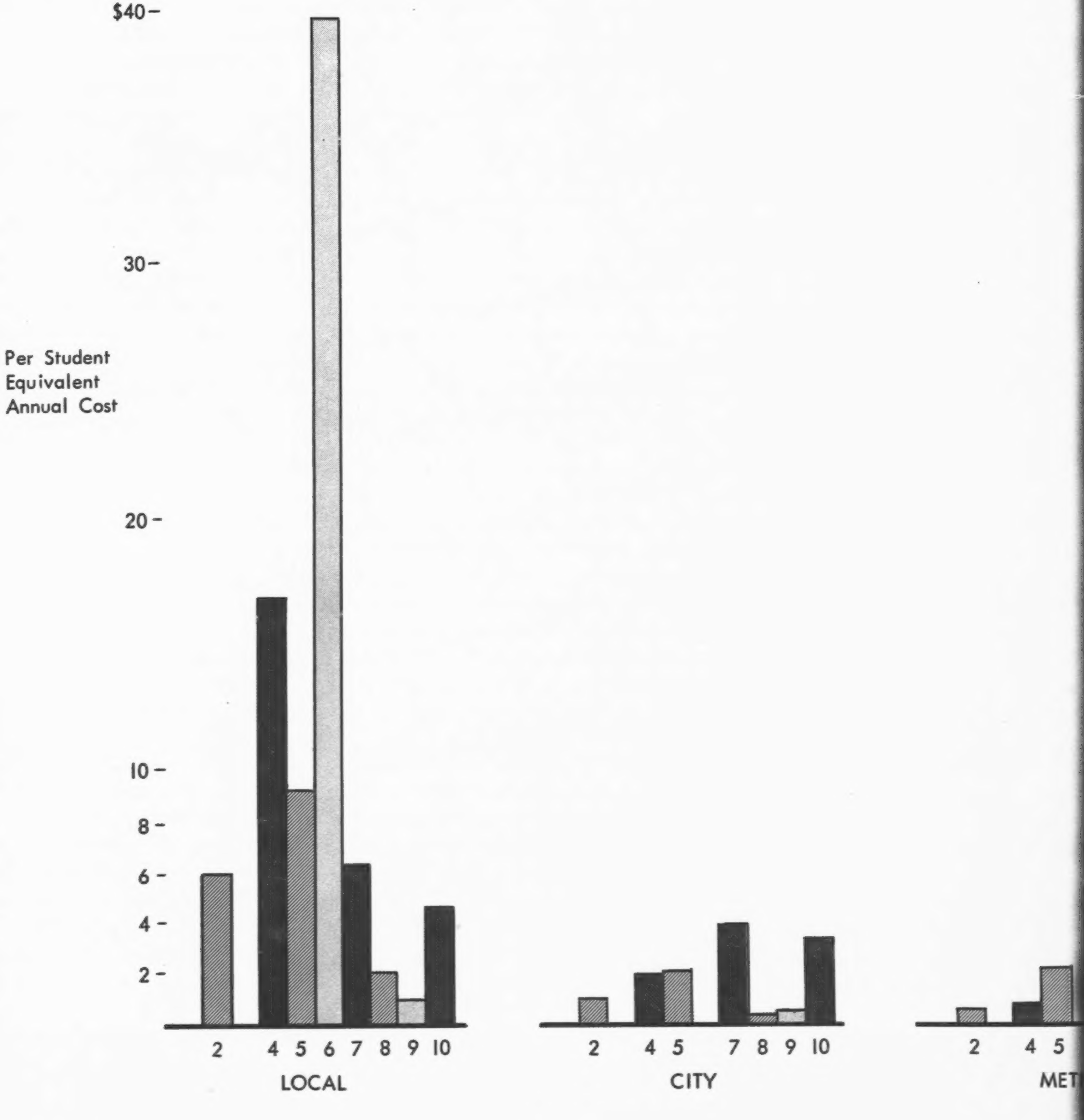
The production cost for the classroom dial access system is quite low, i.e., $2 at the local level and considerably less than $.50 at the city and metropolitan levels. The production cost includes 1,000 hours of tapes of various readings, events, music, etc., which are presently available at a low cost of about $10 per hour. Because the system has 67 channels, and because of the general nature of the material, the instructional technique would largely consist of selecting short segments of the materials by the teacher. The teacher would assemble an instructional sequence for a particular class. This is quite different from the production of radio or television materials where the more limited number of channels assumed in the model means that most of the materials would be organized into complete instructional sequences or series.

In summary, it can be said that production for visual materials can be accomplished at the reasonable cost of several dollars per student if the number of students in the system is in the hundreds of thousands. Moreover, the price structure for the materials must reflect the large volume. At present, television production cost is considerably less than the cost of producing films.

The production cost of audio materials for the 10% task is less than $1 per student when the number of students reaches the level of 100,000. If teachers produce their own tapes or if the somewhat limited number of tapes now available is used, the cost is only a few dollars per student even at the local level. Each of the audio methods is inexpensive to program at the city level.

Distribution Costs

Figure 14 presents the equivalent annual cost of distribution for each instructional media system. The cost of many of the systems which were examined


$40
30
Per Student Equivalent Annual Cost
20
10
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6
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2
2
4 5 6 7 8 9 10
LOCAL
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7 8 9 10
CITY
2
4 5
MET

KEY:

1	AIRBORNE TV
2	ITFS
3	SATELLITE TV
4	UHF TV
5	CCTV
6	VTR
7	FILM
8	RADIO
9	LANGUAGE LAB
10	DIAL ACCESS

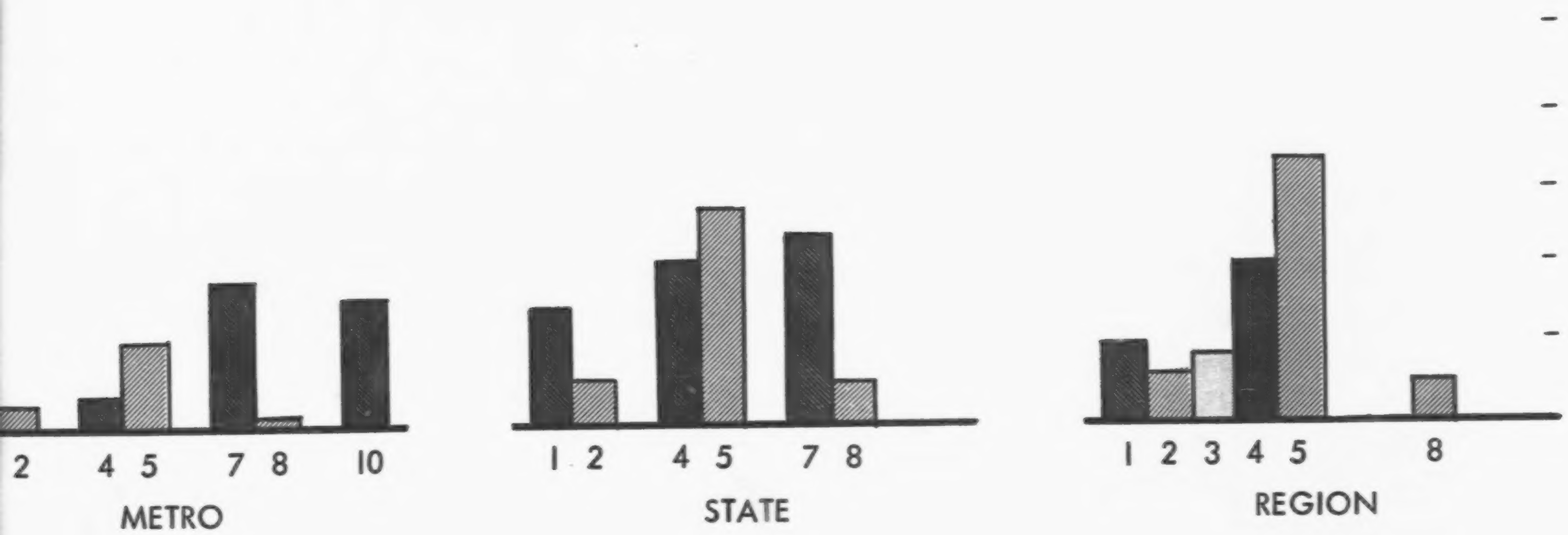


Figure 14. Distribution Cost Comparison

across the entire range of environments show the same type of behavior, i.e., decreasing cost per student in the range from local to city and metropolitan area and then an increase from the metropolitan to the state and regional levels. The change in the number of students per basic transmitting unit of the distribution system causes this behavior. The city and metropolitan areas have densities on the order of 1,000 students per square mile, while the state and regional densities have less than 50. In general, the higher the cost of the basic unit, for example a radio transmitter, the higher the cost per student for the local area but the lower the cost for the larger areas. The local area does not utilize all of the larger systems' potential.

The television distribution systems are relatively expensive to use for the local school system, but become quite reasonable for the city and larger areas at about $2 or less per student per year.

The lowest cost television distribution systems are the present ITFS for local, city, and metropolitan area coverage and the new proposed higher-powered ITFS system for the state or regional areas. The UHF and closed-circuit systems are only $1 per student per year more than ITFS at the city level. It should be noted, however, that the costs for this new type of ITFS equipment are conjectural, since none has been produced or operated. Also, almost all of the cost difference between UHF and the proposed higher-powered ITFS is due to higher power, more attention to providing a readily available signal, better control and monitoring, and higher operational reliability. The two systems are almost the same from a technical standpoint. It would be feasible to change either service to more closely resemble the other, although the FCC would have to approve such changes.

The projected 1973 satellite costs of a little under $2 per student per year and the airborne cost which is slightly more are roughly competitive with the revised ITFS system for larger areas. The cost of the airborne system declines from state to region because the coverage patterns fit together better in a larger area.

The VTR system which places a video tape recorder and tape library in every school is quite expensive at about $36 per student per year. The cost would not decrease for larger areas since the basic cost is multiplied for each school.

The radio distribution system is even cheaper than television, particularly at the local level where it is only $2 per student per year.

The language laboratory distribution system costs about $1.50 per student per year for all of the environments.

The dial access distribution system is the most expensive audio system at $3 to $5 per student per year ranging from the local to the metropolitan areas. The dial access system was not investigated for state or regional areas, but the costs would probably increase substantially because of increased transmission line charges.

The film distribution system costs about the same as dial access or closed-circuit television. The costs are in the $3 to $6 per student per year range.

In summary, television and radio are both available for the city and/or metropolitan areas at less than $1 per student for distribution. In the local school district, the distribution cost of the language laboratory and radio system is considerably less than any other system at about $2 per student per year. The radio system is a high-powered service which can serve homes as well as schools 18 hours per day. Film or classroom dial access distribution can be accomplished for $3 to $6 per student per year depending upon the size of the area. The VTR in the school is not an efficient method using the assumptions presented in the model. Among the television systems, for distribution cost alone, the ITFS system is cheapest for the local and city areas. For the larger areas,only a change in FCC rules to permit higher power will allow ITFS to be competitive with UHF or airborne for the state and region.

It should be noted that effectiveness has not been studied, and that some of the fairly small differences in distribution costs may be offset by educational advantages or disadvantages.

Reception Costs

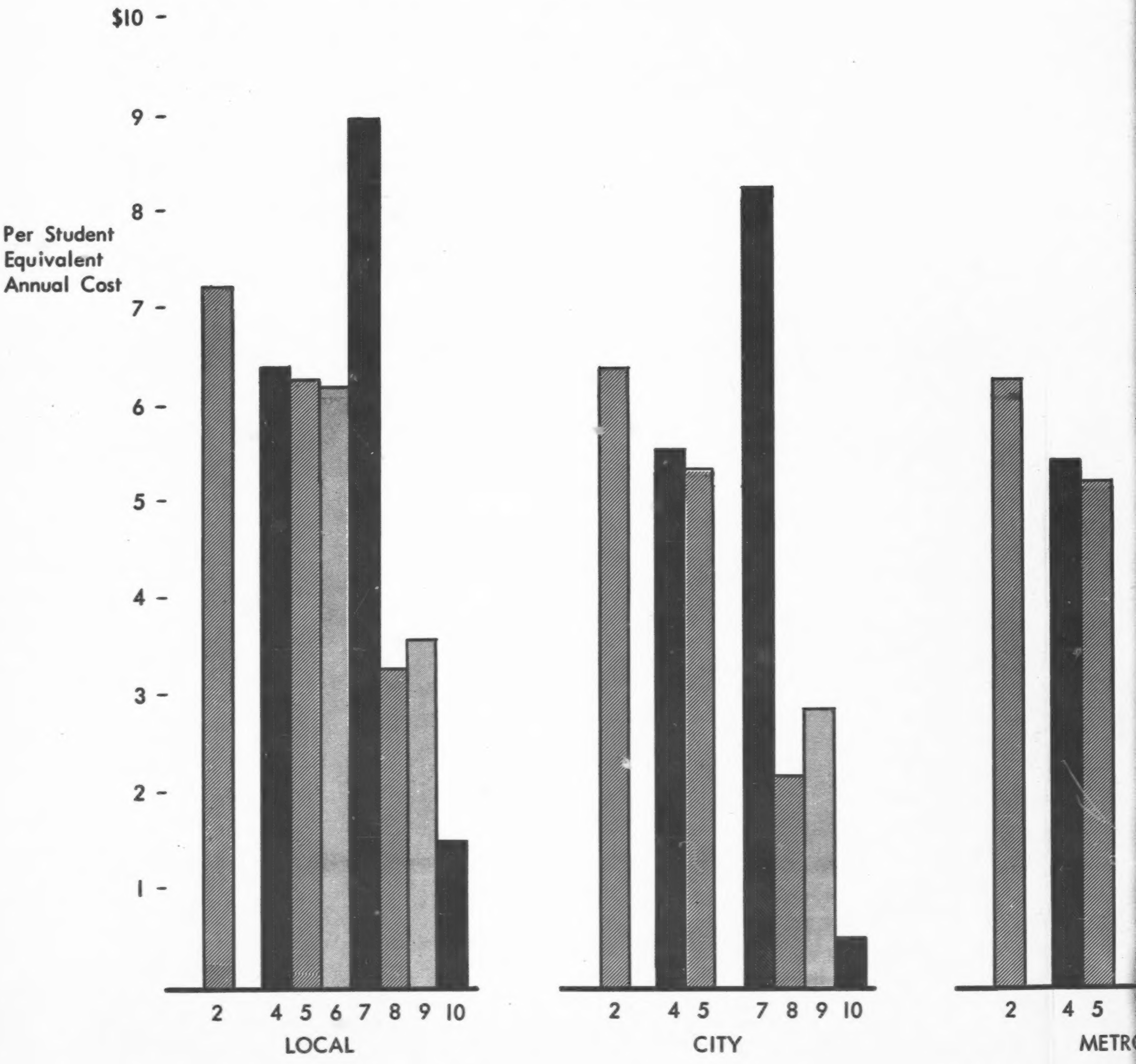
The equivalent annual costs per student for reception are presented in Figure 15. The reception costs show a more constant behavior pattern as a function of area size than do the other costs.

The television costs fall in a band about $1 wide centering on $6.50 for the local system and decreasing to $5 per student per year for the regional system. Closed-circuit, VTR, and UHF broadcasts have the lowest costs. Airborne and ITFS have the highest costs because better antennas and towers are needed. The reception costs for the satellite system are projected at slightly less than the others because 1973 technology is assumed for this system. The present cost for this equipment would be considerably more. Approximately $2.50 of television reception cost per student is for teacher training and another $2 is for the television set.

The radio reception cost decreases from about $3 per student at the local level to about $1.50 per student per year at the regional level.

The film reception cost is about $9 for the local system but decreases to $8 per student per year for the metropolitan area. Film reception costs is the highest of all the media, but is only insignificantly higher than the television reception cost for the metropolitan area.

The language learning laboratories reception cost is slightly higher than radio reception cost and includes the carrel.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Per Student Equivalent Annual Cost
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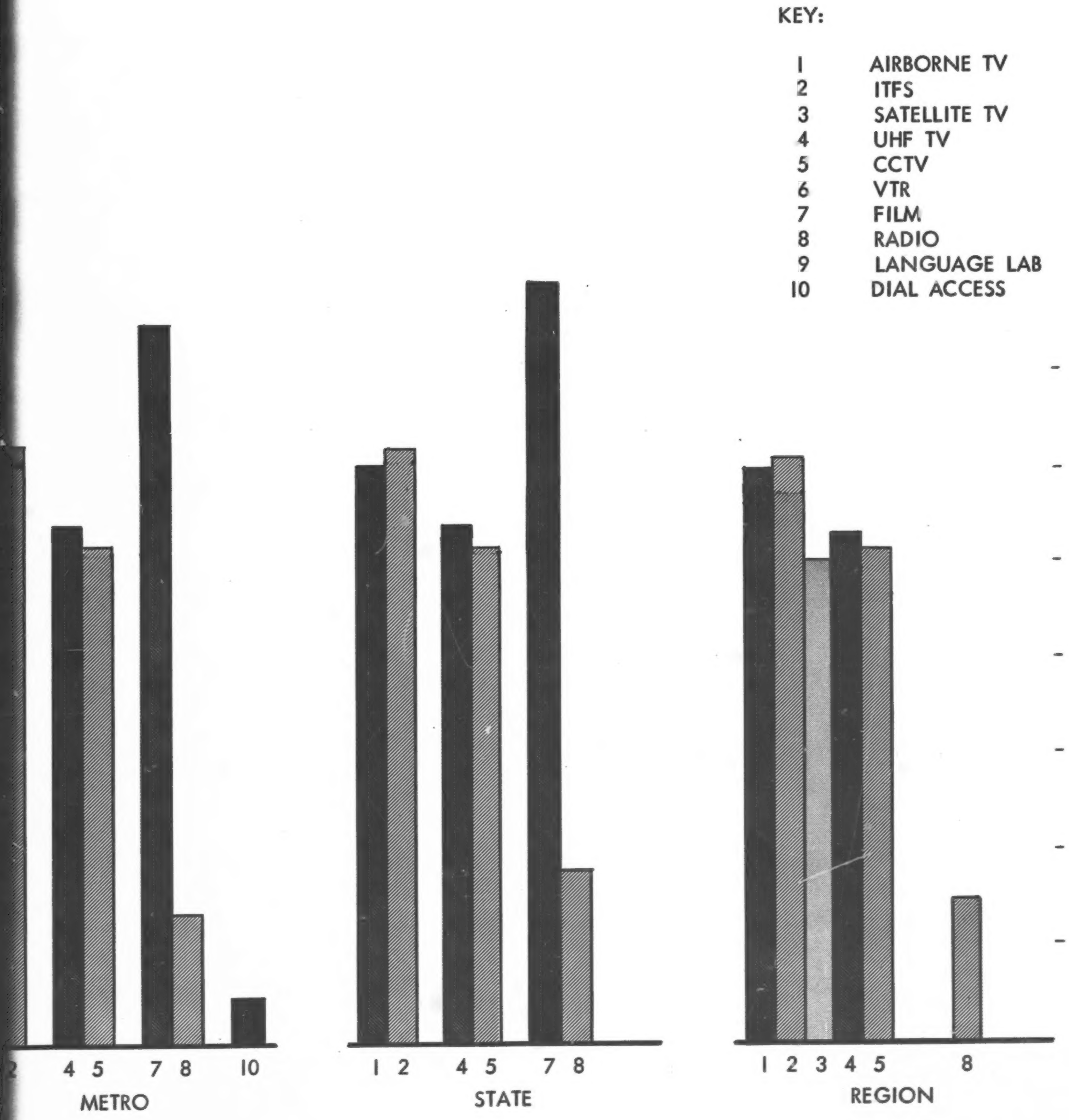


Figure 15. Reception Cost Comparison

The reception cost for classroom dial access is the cheapest of all the media at less than $1 per student per year at the city and metropolitan level. The dial access reception equipment consists of one loudspeaker per room.

In summary, television reception cost, including $2.50 for teacher training is about $6 per student per year. The reception cost for closed-circuit or VTR network is slightly more than the other television systems. Film reception cost is somewhat more. The reception cost for radio is about $2 except for the local area where it is about $3 per student per year. The reception cost for the language laboratory is slightly more than for radio. The classroom dial access cost for reception is very low, about $. 50 for the city or the metropolitan area.

Total Cost

The total equivalent annual cost per student is shown in Figure 16 , and is perhaps the most important cost of all.

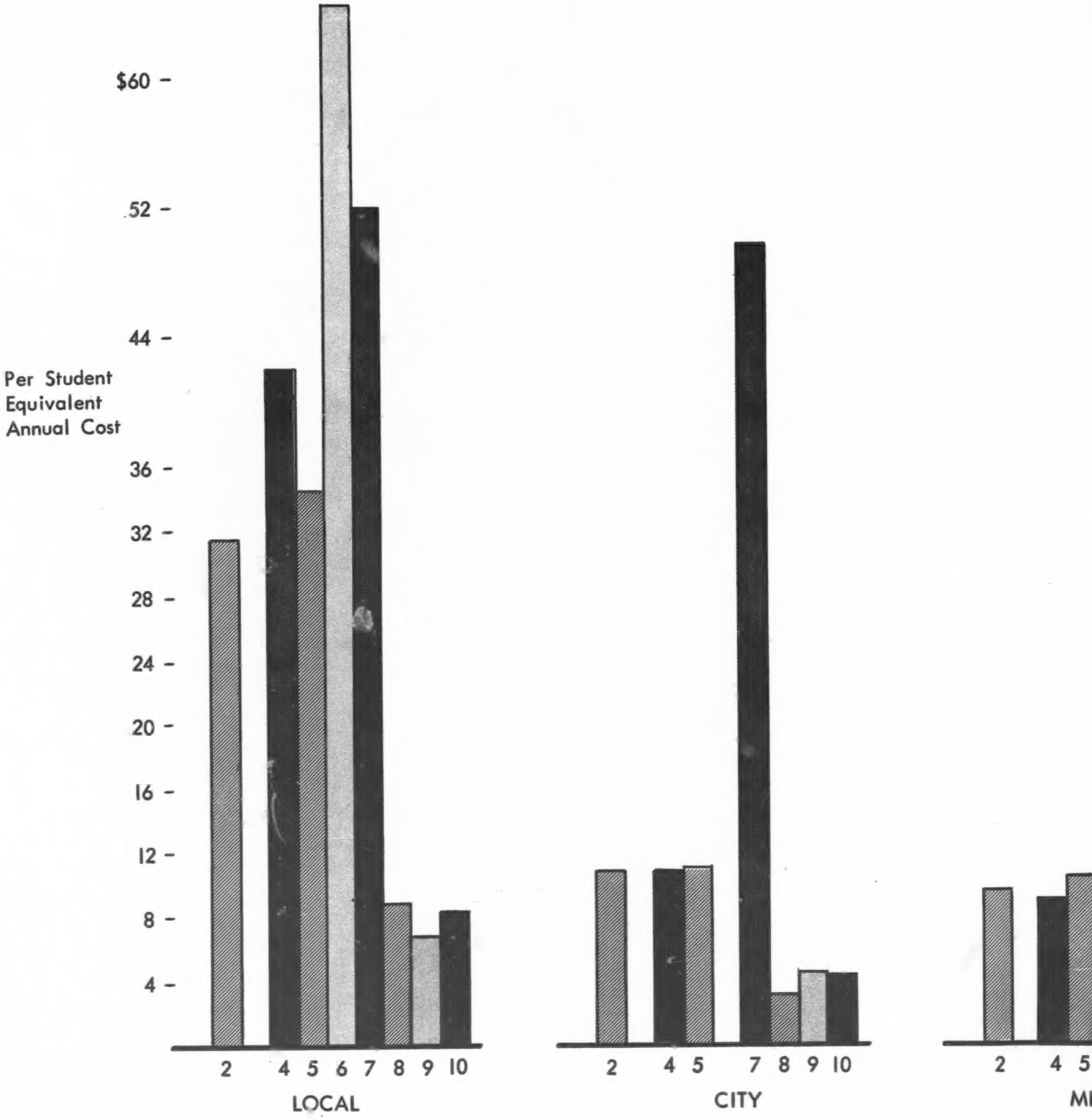
The total costs fall into two broad bands with only a few exceptions. The television total costs (except for the VTR system) fall between $30 and $40 per student per year for the local area (5% to 10% of yearly expenditures.) They converge on $10 for the city and roughly the same for the metropolitan area. They then increase to the $6 to $14 range for the state and regional areas. The 1973 satellite has the lowest total cost but only by an insignificant margin. The ITFS system is less in the local areas. For the city and metropolitan areas, costs are so close that technical questions of channel space would probably be more important and would no doubt favor the closed-circuit system. Much the same can be said for statewide multichannel systems unless FCC rules are changed.

The results for the audio systems, language learning laboratories, classroom dial access, and radio systems form the second band and all fall in the $8 to $10 range for the local area and in the $ 3 to $6 per student per year range for the city. The radio system is about $2. 50 per student per year for the metropolitan area and $3. 50 and $2. 50 for the state and region, the lowest cost of any system.

The VTR system with video tape recorders in each school costs about $65 at the local level, considerably more than any of the other systems. As cheaper and more reliable machines, high speed duplication, or the CBS Laboratories' EVR system become available, VTR should be given additional attention.

The total costs for film are about $50 per student for the local, city, and metropolitan areas, but rise to about $59 per student per year at the state and regional level.

In summary, audio instructional materials can be supplied by radio for as low as $2 to $3 per student per year. Visual material costs are about $10 per student per year when they are delivered by television in the city or metropolitan areas. Several new methods are available for coverage of wider areas at about the same or slightly lower cost. Smaller school districts must cooperate with one another or pay considerably more.


$60
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Per Student Equivalent Annual Cost
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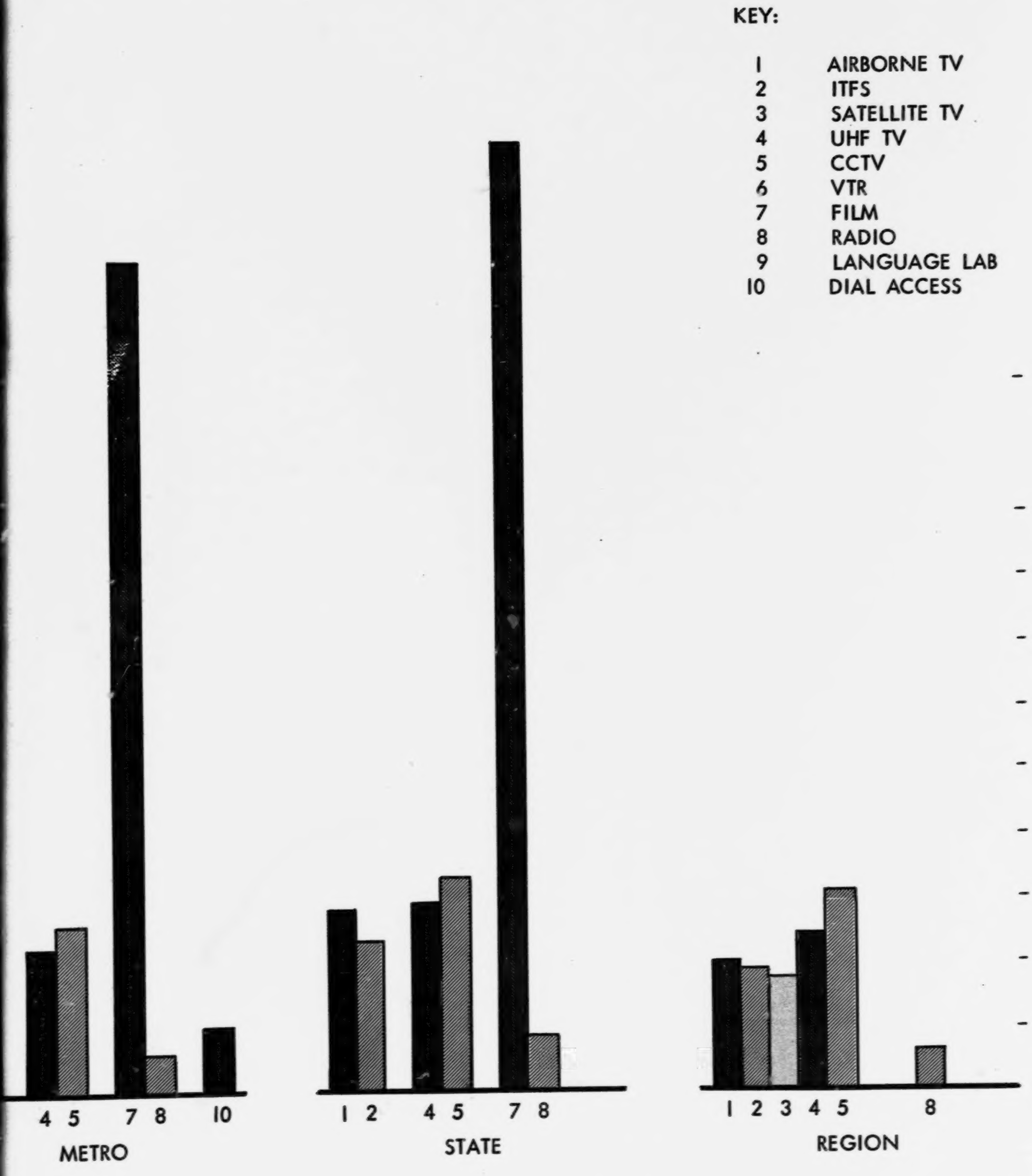

Figure 16. Total Cost Comparison

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Effect of Number of Channels and Task Size on Cost Per Student

The cost figures presented in the discussion of television and radio have been costs for a four-channel service. The four channels accommodate the defined task of 10% of student time with a considerable margin for repeated broadcasts and expansion. There is, of course, the possibility of changing the task and/or changing the number of channels. An estimate of the cost of doing this is shown in Figures 17 and 18.

Figure 17 presents the change in cost with a downward change in the number of channels from four to two and one for selected television systems. The figures are obtained from those in the descriptions using the same production and reception costs per student and the distribution costs for one and two channels. It is assumed that a single six or eight-channel converter to UHF can be designed. The additional cost is quite small, little more than $1 for six or eight channels. Regulatory limits on the number of channels might preclude such additions, however.

Figure 18 considers the effect of a change in the level of the task accomplished by the instructional media system. The basic level of the model is 10% of student time. For a 20% task, the programming portion of production cost would almost double. Other costs would remain about the same. The result, roughly a 20% increase in total cost, is shown in Figure 18 for the closed-circuit metropolitan system. Other television systems at the metropolitan level would change the same amount given the above assumptions.

A combination of the two changes — a 20% task and an eight channel system — would result in an increased cost of only about 30%. This is a very crude estimate.

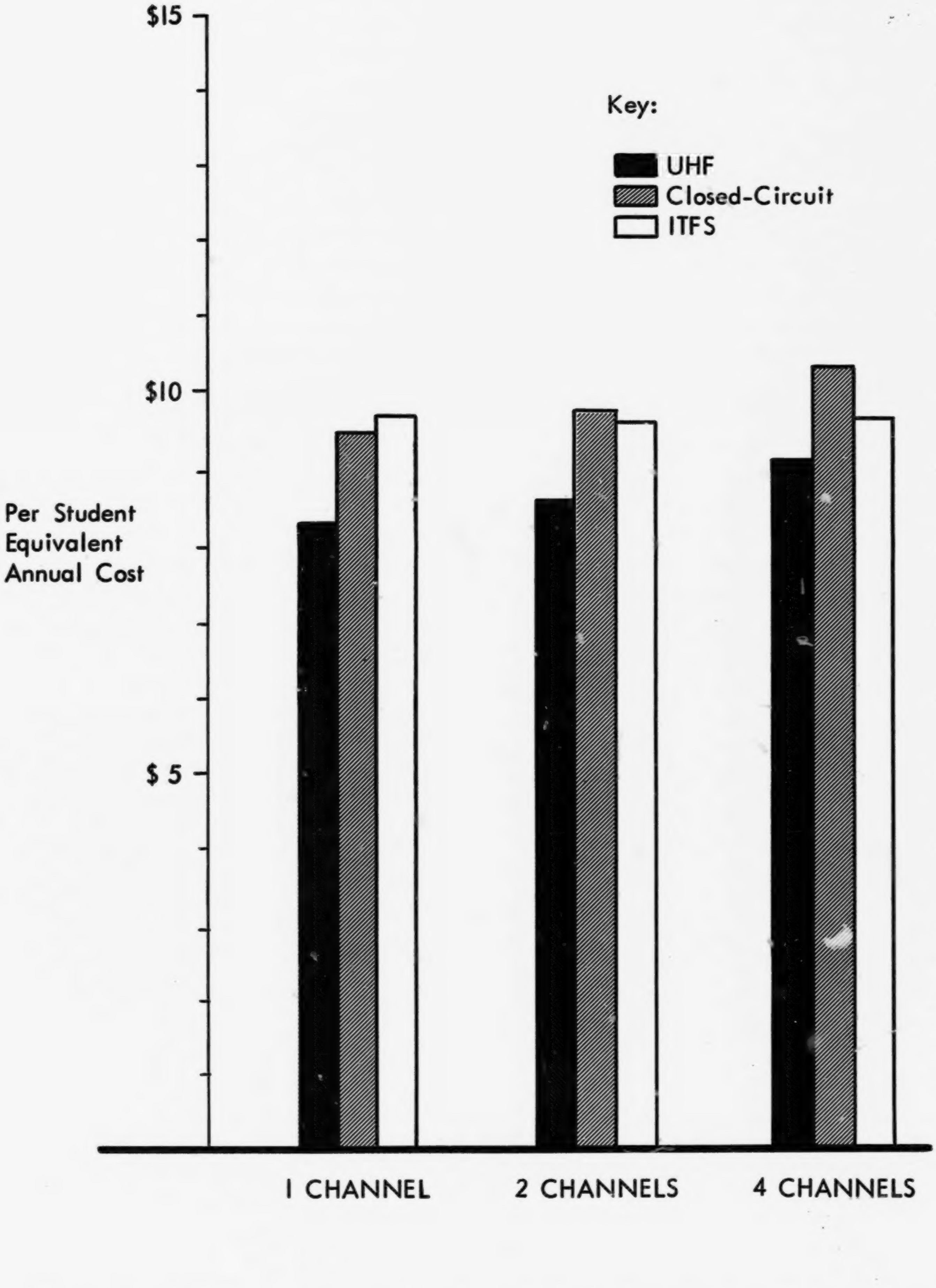


Figure 17. Estimated Effect of Number of Channels on Cost - Metropolitan Area

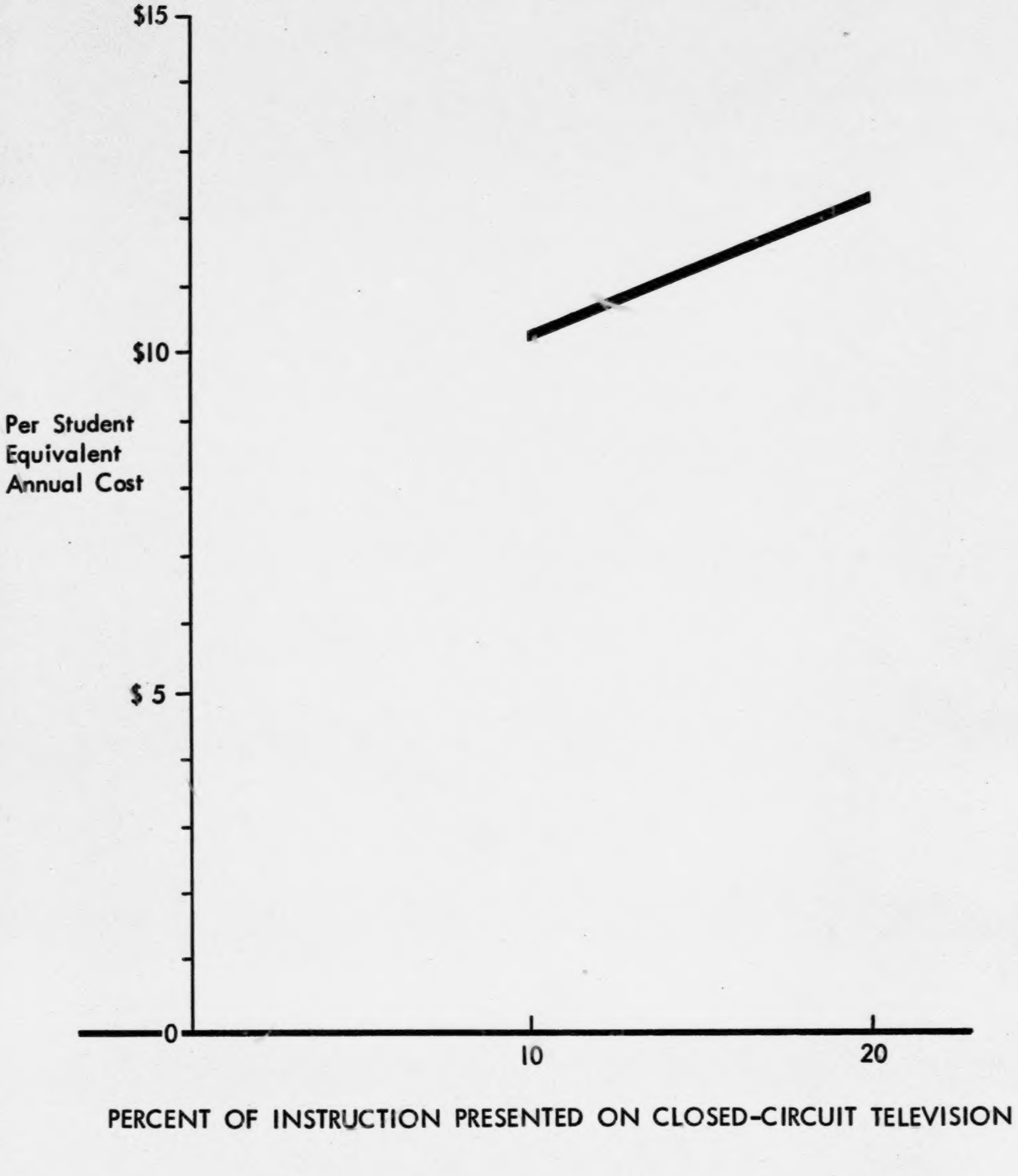


Figure 18. Estimated Effect of Task Size on Cost - Metropolitan Area

COST-SAVING CONSIDERATIONS

One objective of this study was to investigate ways in which costs of instructional media systems could be reduced. Since this objective is an integral part of the study, no attempt has been made to isolate cost saving considerations and discussions from other sections of the report. Therefore, this section serves two purposes. The first is to present an overview of how cost savings may be achieved. The overview includes references to some of the cost saving discussions contained in other sections of the report. The second purpose is to present additional suggestions which may lead to possible cost savings through organizational changes in the educational systems.

Three areas can be identified where changes are necessary if cost savings are to be achieved. These areas are:

- The utilization of media systems,
- The technology of media systems, and
- The organization of educational systems.

A discussion of each of these three areas is presented in this section.

Utilization of Media Systems

Wide-scale adoption and more intensive use of the media will result in cost reductions on a per student basis in the areas of production, distribution, and reception.

Production Cost Savings

Significant savings will result if a production effort can serve a larger number of students. However, if materials are to be accepted for widespread use, the quality of content and presentation must be improved by making more effective use of learning theory, techniques to motivate students, and studies of the curriculum needs of the schools. Preparation of materials in this manner would result in an increase in overall production cost but, through wider utilization, would also result in a decrease in production cost per student.

Savings in quality production are predicated on the assumption that the need for materials is relatively uniform in widely scattered school districts and that reliable, convenient distribution and reception systems would be available to transmit these materials. The existing widespread adoption of the same textbook would seem to indicate that these assumptions are reasonable. However, some mechanism is needed to guide the production and distribution of materials for the newer media, and the cooperation of school districts is an essential ingredient in the development of such a mechanism.

Figure 2 on page 20 illustrates the cost savings possible through wider utilization of the materials produced for television. The cost per student drops rapidly with the increase in the number of students served. This cost decrease occurs although there are two assumptions in the model which would tend to have the opposite effect: (1) the number of hours of material required increases 60% from the local to the regional environment and, (2) the quality of material changes from "minimum" at the city level to "high" at the metropolitan level.

Distribution Cost Savings

The distribution cost per student can be reduced if

- More students can be served from a central facility, or
- Mass reproduction methods can be found for making inexpensive copies of original materials.

The service of a media system can be increased through the use of network television techniques - higher transmission antennae, increased transmission power, and the electronic relay of materials between school districts. Satellite and airborne television systems are also well suited to covering vast areas containing large numbers of students. More intensive use of such methods can reduce per student cost considerably, but only if materials and schedules are appropriately tailored to the educational needs of participating schools. To accomplish this, transmission centers must have multiple channels available, and schedules and materials must be coordinated.

Figure 19 shows the behavior of distribution cost for broadcast television systems as a function of the number of students served. The cost per student decreases sharply over the range from the local to the metropolitan level. On the other hand, no decrease occurs from the state to the regional level because the population density does not increase; or, in other words, the utilization of any one station does not increase from the state to the regional level.

The critical factor in lowering the costs of reproducing original materials is the anticipated volume of distribution. Unless the volume is large enough, the development effort required to find inexpensive methods of duplicating films and video tapes would not be worthwhile. Present copying techniques are based on high quality broadcast standards and low volume. Although high speed reproduction of video tapes is potentially possible, the necessary techniques have not been developed. The price of a film print is many times the cost of making the print because of the low recovery rate of production and marketing costs. Assurance of a high volume market for copies of video materials or Federal financing of the needed research of low cost reproduction methods would lead to cheaper methods of copying video educational materials.

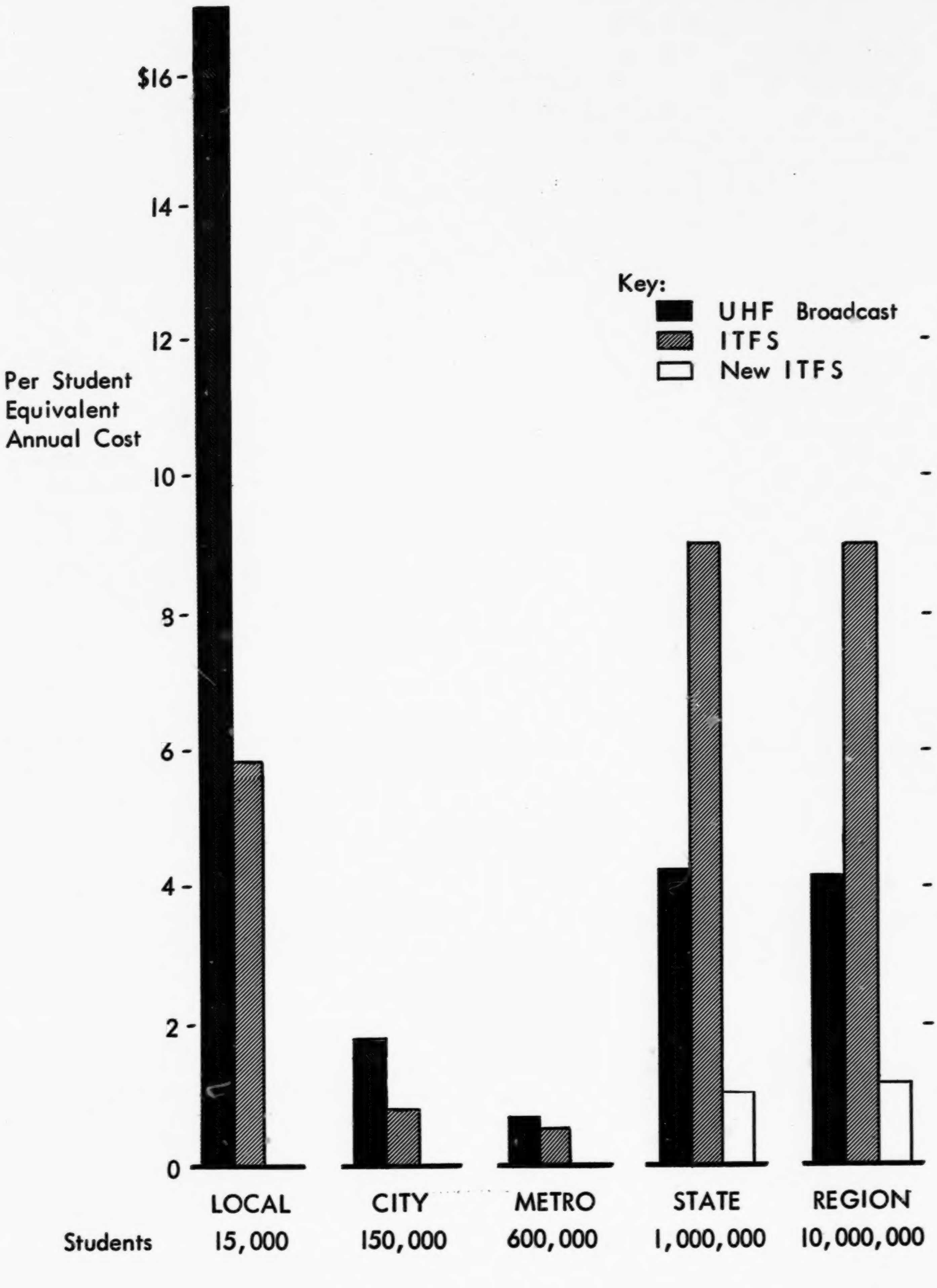


Figure 19. TV Distribution Costs

Reception Cost Savings

Savings in reception costs can be effected through

- Increased student utilization of some portions of the reception system, and
- Lower costs of components through the adoption of mass production methods.

Portions of the reception system would cost less per student if more student hours were devoted to the media. The central reception and distribution segments in the television reception systems are examples of areas where greater utilization would lower per student cost. However, since most of the reception cost is for the television set and teacher training, more students in the schools would not necessarily lower costs per student. The students would still need a television set and a trained teacher.

The discussion above shows that an increased number of students using a media system tends to lower per student costs. Also, there is another increase in the utilization of the media which would tend to affect cost favorably, i.e., the increased use of the system by the same students. Although the actual cost per student would rise as the system is expanded, the cost does not increase as rapidly as service is increased. (See the discussion on page 44 regarding the effect on cost of expanding the educational task. Also, reference is made to Figure 17 on page 45 which illustrates cost as a function of the number of channels.) Therefore, if total educational costs are considered, more intensive use of the media systems may be desirable since the change in the cost of providing additional units of instruction is quite small.

Improved Technology for Instructional Media

Improvements in the instructional media technology should lower the cost of the media. Several technological advances are suggested in this volume. For example, the satellite (see page 141) system is not now in existence; the higher-powered ITFS system (page 130) is a new proposal. The suggested use of a four-channel television system (page 112) would also be an innovation. Some aspects of the classroom dial access (page 280) and language laboratories (page 246) are new. The multiplex radio system (page 223) is not now in educational use. In addition, the second section of the Appendix presents several suggestions for new instructional media systems which have not been costed as systems because they are too new.

Organization of Educational Systems

Volume I, "Guidelines for Determining Costs of Media Systems," describes behavioral objectives and the types of learning associated with those objectives as key elements in the media selection process. The mode of presentation, group or individual, is also an important consideration in the selection procedure. If these elements play a part in the selection of a media system, it may be assumed that the need for both group and individually-oriented systems will be recognized. Would this change the traditional school organization? Yes, because there are few provisions for individualized instruction at the present time. Could these changes result in "cost saving" situations? Again the answer is "yes".

The cost savings which could result from changes in the organization of educational systems should probably be referred to as increases in "cost effectiveness." Most of the previous discussion has tended to equate cost savings with reduced costs. In this discussion cost savings will be equated with cost effecttiveness.

The largest item in a school's operating budget is teachers' salaries. The implementation of media systems would not necessarily reduce the number of teachers. It would alter their role, however, so that they could devote a larger portion of their time to individual instruction and the guidance of learning experiences. This would be one step toward the achievement of optimum "cost effectiveness". The operation of media, the monitoring of learning experiences, and other similar responsibilities could be assigned to paraprofessionals. This work, currently performed by the teacher, could be effectively accomplished by persons without the professional qualifications required of members of the teaching staff. Hence, a "cost saving" may result when a school system is organized along these lines.

The discussion of wider utilization of media systems indicated that cost savings are possible when the system is used by larger numbers of students. For example, a dramatic decrease in annual cost per student for the production of television material occurs as the number of students increases from 15 thousand to 10 million. The per pupil cost of the distribution portion of the media system is also favorably affected as the number of students increases in the area served by the system.

Wider utilization may reduce cost, but it may also present organizational problems. For example, if 11 states were to be served by the same instructional satellite system, the educational programs of those states must be coordinated.

If production costs are to be shared, the material must be acceptable to all of the participants. Therefore, the user schools must be involved in the design, development, testing and evaluation, and revision of materials. The financial arrangements to support the production of materials must be agreed upon. All of the above considerations would affect the present organization of the user schools.

A distribution system which serves more than one school or district also presents problems. The scheduling of "what and when" can be a horrendous task. Again, the organization of the schools using the system is affected by the scheduling. Therefore, these schools must cooperate to determine the policies of a central distribution facility.

The media cannot be effective unless the teacher, the director of the learning experience, is trained to make use of the capabilities which the media system provides. Therefore, teacher training is of prime importance, and the educational system must provide adequate training. Teacher training may tend to increase per student cost, but lack of training in the use of the tools provided by media can affect cost effectiveness immeasurably.

The scope of this report does not include the investigation of designs for the effective organization of educational systems, but this discussion has been included to point to some of the ways in which media system cost reductions and cost effectiveness are related to the organization of the educational system.

REGULATORY IMPLICATIONS

Electronic Systems

Some of the multichannel instructional television systems proposed in this study are not explicitly covered by the present regulations or policies of the FCC. Specifically, the higher-powered ITFS specified for the state and region, the four-channel UHF system, the UHF airborne system, and the use of satellites for direct transmission on the 2500 MHz frequencies are all somewhat outside established practice. These departures were made for two reasons.

The production costs for instructional media for the local school system of 15,000 students were found to be $60 per student per year for high quality programming, $15 per student for minimal quality programming, and $6.67 for copies of materials produced by national sources. The distribution cost was almost $6 per student, even for ITFS, which has the lowest cost. These high costs decrease as more students are served and should encourage schools to share production and/or distribution efforts by joining an area-wide system such as a metropolitan, state, or regional system.

The possibility of a wide area multichannel instructional television system is limited under present FCC regulations and policies. An examination of the policies regarding multichannel wide area systems shows that these limitations make it impractical to implement a large scale instructional television system outside of a metropolitan area.

The UHF frequencies are designated as broadcast frequencies. The Communications Act of 1934 defines broadcasting as "the dissemenation of radio communication intended to be received by the public." The FCC regards this definition as separating instructional television from broadcasting since ITV is not intended for the entire "public." FCC policy is that instructional service, if designed for instruction alone, should not be placed in the UHF band. Multiple channels would be particularly hard to obtain for educational purposes. Recent FCC actions which give evidence of this viewpoint are the denial of the NAEB request for multiple-channel educational reservations in the latest UHF allocation table, the denial of the Georgia State Board of Education petition for a block of 30 UHF channels, and the refusal by the FCC to allow the airborne television project to continue using the UHF channels assigned to it.

The FCC has specifically allowed educators to use the 2500 MHz band on a shared basis with other users for a three year period ending in 1966. As of 1968, no final action has been taken. This service, the Instructional Television Fixed Service or ITFS, was set up at the urging of an electronics firm which desired an additional market for its low power microwave relay transmitters. The ITFS service is a low power, localized service for individual school systems. Use of low transmitting heights and directional transmitting antennas is recommended. Paragraph 26 of the Report and Order on Docket #14744 of the FCC specifically bans use of ITFS "to distribute material over an entire state or a large portion thereof." Even when used within a metropolitan area, the FCC concept of shared use of ITFS channels has required the concurrence of all school districts in the area before service can be instituted. The ITFS service is not economical for wide area coverage as is shown in the ITFS cost figure for state coverage.

The airborne system was given until 1969 to relinquish its UHF channels. Meanwhile the FCC designated six ITFS channels in the midwest for its use. Airborne broadcast on even four ITFS channels in any area except that covered by the midwest airborne project would have to obtain the explicit permission of all school districts within its area, according to the present FCC policy. This would be difficult. Thus the only operational airborne system is now in its final year, and the idea probably will be hard to revive.

The use of a satellite for direct telecasting is not covered by FCC regulations. There are strong political and economic forces that must be overcome before such an operation would be approved.

The only alternatives to the telecasting methods discussed above are closed-circuit systems and the portable video tape recorder, neither of which uses the airways. These are by far the most costly systems as is shown in Figure 16. Neither of these systems is within the province of the FCC unless microwave is used or state lines are crossed.

In summary, the use of the airwaves for multichannel instructional television for a wide area has been almost precluded by present FCC regulation and policy. Since such a system has considerable cost advantages, several instructional media systems which would be difficult to establish under present FCC policies and regulations were included. The systems which are specified can be justified in terms of channel allocation and the economics of providing the service if a priority were assigned for instructional service. A brief justification for each of the systems follows.

The four-channel UHF instructional system could be accommodated if the FCC would recognize the difference between instructional service and other broadcasting. The taboos, limitations on close spacing of channels, which do not apply to instructional service could be changed. The taboos were eliminated for ITFS in recognition of this fact. Reservation of a block of channels for instructional systems was thoroughly studied for the Georgia State Board of Education proposal and found to be practical. A block of 20 channels would be sufficient for a four-channel state or regional service. In the UHF channels 52-72 or 63-83, there are only the merest handful of broadcast stations operating. This could be moved down into the region below 52 to 62 if some of the allocations to small communities were deleted from the allocation table or if a more "saturated" allocation table were prepared. It has been shown that the great majority of the UHF station allocations will not be used in the foreseeable future because they are not economically feasible. It has been said that the FCC is thinking of transferring a portion of the UHF broadcast channels to the land mobile service for this very reason.

The four-channel airborne system was generally assumed to be operating in the UHF in this study. However, it was noted that the transmitting equipment could be produced for about the same price at the ITFS frequency. Thus, the airborne system could operate at either frequency except for regulatory considerations. Extensive analysis of the allocations in the midwest in 1964 showed that there were adequate channels available for both a six-channel airborne instructional system and all the commercial stations which would be economically feasible in the foreseeable future. The same is probably true for all regions except the eastern megalopolis, which has been treated in a separate statement in this study.

The low power of the present ITFS system does not make it economically feasible for use in a large area. For this reason, a higher-powered, wide-area ITFS service is proposed in this study. The reason for examining the state and regional areas is because the local school system can not afford programming for the multichannel systems. A state or regional system is the only way to serve the small school districts if they are outside of a metropolitan area. While the local school system may find scheduling advantages in the use of ITFS, there are serious problems of financing the production of materials for telecasting. The FCC's recent pamphlet on ITFS points to the desirability of renting materials rather than producing them in each school system. Unfortunately, there are not adequate rentals available and even rental is expensive for the small school system. Many schools are proceeding with live production without adequate resources, personnel, planning, or experience. Many thousands of schools will soon undergo the frustrating programming experience which ETV stations have experienced during the last 15 years.

The proposed higher-powered ITFS system would include a 20 channel block for the state or regional system, leaving four to six blocks of two or three channels per block within the present ITFS allocation for purely local use or for local retransmission to avoid scheduling problems.

The satellite system in this study is on the same frequency as ITFS. It is assumed that provision could also be made for a few channels of local ITFS service, as would be done with the higher-powered ITFS.

The problem of frequency allocation is currently under inspection by several groups on a national and international level. This is a particularly opportune time to make adequate provision for instructional television.

In summary, without a national program source, only a state or regional system can economically provide instructional television for the local school. The FCC does not provide for such a system. Therefore the assumption has been made that the regulations can be changed. It is suggested that economical and efficient four-channel systems can be instituted at either UHF or ITFS, leaving sufficient channels still available for local commercial and educational interests.

Film System

Some cost efficiencies in a 16mm media system could be realized with a favorable outcome of the current copyright legislation. Unfortunately, Congress is trying to develop a piece of universal legislation that will satisfy both the author and the publisher of all art forms for all communication media, both commerical and educational. A proposed draft of suggested copyright changes was authored by members of National Association of

Educational Broadcasters for the Department of Audiovisual Instruction of the National Education Association. The bulk of this draft was adopted as the official position of NEA who then recommended the changes to Congress. These recommendations have provoked considerable discussion during the past two years.

The fair use doctrine was expanded to permit a school to make one copy of a film without obtaining permission from the copyright holder, use it once, and then destroy the copy. Certainly this clause can only tempt honest individuals to break the law. On the other hand, modern photocopying equipment allows individuals to infringe upon the existing law every day. The textbook publishing industry has helped to create this problem by refusing to allow teachers to duplicate passages from books for testing purposes. Schools are permitted to make a duplicate video tape copy of an existing film program, but it is doubtful that they will destroy the copy once it is made. Accordingly, most producers and distributors charge exorbitant prices for schools for the right to copy. They feel that permitting video tape copies of films will decrease their sales to a school system because the schools will use the multiple transmission capabilities of television rather than buy enough films for the classrooms. No research has been done to prove or disprove this argument. A research proposal to study this matter has recently been submitted to the Department of Audiovisual Instruction of NEA.

Another area of infringement, according to legislation now in effect, is excerpting short segments of footage from longer films. This can be resolved easily by establishing a national facility which would catalog existing film footage, source, and price. Footage cataloging is virtually nonesistent today and would require computer cataloging procedures to describe sequences.

A difficult area which the proposed copyright bill avoids concerns films that were produced by Federal government grants. A few years ago marketing or distribution rights for films, texts, and other materials were given to corporations who then priced these items at commercial rates. Competitive companies complained about the exclusive distribution rights; educators complained about the commercial prices; and the Federal government was in the middle. No group of commercial companies would cooperate and market the programs on a nonexclusive basis. Also, they would not allow the program development agency to market their programs because they feared government competition.

As curriculum development programs continue to be funded by various agencies of the Federal government, some nonexclusive distribution contracts have been negotiated. However, a new problem has developed. Publishers, distributors, etc. refuse to accept a program the way it is designed, but rather wish to change content and/or form to be consistent with their own programs or manufacturing capabilities. For example, if a program consists of 10 odd sized booklets each having 10 pages, a publisher would package it in one volume of standard textbook size of 100 pages. One solution to this problem is to fund the curriculum groups and allow them to develop their own distribution capability. Another alternative is to help individuals from the educational and commercial communities to establish new companies for this purpose by funding the initial capital requirements of these groups. Currently the Small Business Administration is slow to loan money for the formulation of this new type of company.

In summary, if a national program source is not available, 16mm film programs could still become less expensive if the following steps were taken.

Redraft the current copyright bill to better serve the needs of educators and commercial producers.

Create a national cataloging service so that schools can locate short film segments that best fit their needs.

Permit films that were produced with Federal funds to be sold at less than commercial prices.

Permit curriculum groups to market or distribute newly developed materials.

CONCLUSIONS

To quote from the summary of the study, the purpose of this study was ... "to investigate the cost of instructional media systems. The first objective was to provide the educator with a set of guidelines for realistically estimating the total cost of such systems. To gain this objective it was necessary to identify and investigate a set of commonly used or proposed media systems and to develop a methodology for determining total system costs. The data collected and analyzed during the study achieved the second objective of providing a data base for use by researchers in further studies relating to the selection, implementation, and operation of instructional media systems. A final objective of the study was to present recommendations which can result in cost savings when media systems are used. These recommendations are in the areas of media utilization, application of new technology, and educational system organization."

The actual accomplishment of these objectives was not attempted in a sequential fashion because there is continuous interaction among method, data, and definitional questions in a cost study. Methods are determined partially by the availability of data and the scope of the study. The data collected and the processing of the data depend upon the analytical methods to be used and the systems definitions. The definition of the systems in a cost study must inevitably depend upon the data base or the study becomes a design study. Thus, the three objectives interact continuously. For this reason, it may be well to review the accomplishments of the study in a more integrated fashion. This discussion will be organized into three elements.

1. The identification of those areas where the instructional media system interfaces with its environments.
2. The structure of the costs of instructional media systems.
3. The comparison of the costs of instructional media systems.

Interfaces of Instructional Media Systems with Their Environment

One of the most difficult tasks in a system cost study is to determine the boundaries of the system and the effects of the environment at those boundaries on the cost of the system.

The Educational Boundary

The most important boundary is between the instructional media system and the elements of the educational system, i.e., the student, the teacher, and the educational administration including the curriculum specialist.

The boundary with the student is relatively clear-cut since most of the systems studied are passive. The complete cost analysis of interactive media such as computer-aided instruction must await better information on student response.

The interface with the teacher is extremely important. The teacher needs two types of information in order to use the instructional media system effectively - general information on integrating media into the classroom activities and specific information relating to the availability of materials for the media. Both of these requirements must be met in order to have the system function properly.

The cost of providing the first prerequisite, media training, is extremely high. Only a small attempt was made to meet this need, i.e., summer training for 10% of the teachers. Nevertheless, the cost of teacher training is about 40% of the reception costs. To insure the success of media in education will require a substantial effort by all the institutions involved in teacher education over a long period of time.

The cost of providing the second type of information, current availability of materials, is not as great as for teacher training. Unfortunately the schools have a tremendous problem with the flow of information from central sources to the classroom and vice versa. Ideally, the media should improve this situation since they are communication devices. In the past, information regarding the media system itself has been added to the existing information channels, and the possibility of using the media to communicate has been ignored. In the specification of systems for the cost study, an attempt was made to include this capability. In addition, costs are specified for other means of communicating with teachers.

The interface of the instructional media with the educational administration has not been well defined. The importance of planning for the selection and installation of media systems has not been thoroughly understood. The administrator is often persuaded to purchase a particular media system by specialists or others who are convinced of its superiority. If instructional media are ever to realize their full potential, they must be considered a part and not an appendage of the educational system. Their selection must grow out of the desire of curriculum specialists, teachers, and the entire educational administrative system to achieve educational objectives. The media systems cannot be disregarded after they are installed. They must function as a part of the feedback system for the continuing design and testing of the educational experience. Otherwise, even a system that is well-conceived initially rapidly becomes outdated. Planning, administration, and testing and evaluation funds at a reasonable level are included in the study.

The Knowledge Industry Boundary

Another important interface of the individual media system is with the knowledge industry, broadly defined. The schools look to the knowledge industry for educational materials and for the purchase and maintenance of hardware system components. The approach of the knowledge industry has not been matched to the needs of the schools. This may be due partly to a refusal by educators to commit sufficient time to define the problem adequately and enough money to recompense industry adequately for developing useful systems.

Even a relatively simple need such as the reliability and service of equipment has not been met adequately. A recent report on media in 10 city school systems pointed out that television reception was severely hampered by problems of reliability and service. These problems are particularly acute in the newer media systems which are usually not well designed for day-in, day-out use by students and teachers. Trained, equipped servicemen are not always available. Returning components to the factory takes too long and requires stockpiling and shifting of spares. The cost study attempted to overcome the service problem by generally specifying the more reliable equipment and providing full-time operation and maintenance personnel plus a 5 or 10% yearly maintenance cost. Even these costs are probably not adequate unless industry provides better support. A similar problem concerns the fact that new media, such as portable video tape recorders and 8mm film, are not standardized. Lack of standardization limits the availability of materials and handicaps service.

In the more difficult areas of providing educational materials for a custom designed system, the knowledge industry has also failed to provide the type of service schools require. There are almost no commercially available video taped instructional materials. Although films are available, the print prices are too high for extensive use. A large volume market would support development of films and tape at reasonable prices. What is needed is a mechanism for planning and developing the materials for wide acceptance in the schools. The cost study estimated television production costs for both high quality materials and for minimum quality, locally produced programs. Since there is no existing source for the high quality materials, the smaller environments are forced to use lower quality materials produced locally at a high cost per student.

At present, most instructional media systems are sold by manufacturers with a narrow line of equipment. The manufacturers are one of the school's main sources of information. As a result, schools often install systems which are not well suited to their needs nor matched to available materials because they have been advised by manufacturers who are not familiar with the entire system.

Finally, the knowledge industry has been supporting copyright provisions which handicap the multi-media approach to educational materials. It seems that a copyright provision is needed which is based on the content of the materials rather than on the specific media by which they are presented.

The Government Boundary

The last important interface of the instructional media system is with the Federal Government. This interface is primarily with the Department of Health, Education and Welfare for funding and with the FCC for licensing.

The Department of Health, Education and Welfare has several programs under which funds can be made available both directly and indirectly to schools for instructional media systems or materials. Publications and support of teacher training in the application of instructional media systems are also provided. The variety and separation of these programs (see reference 194) makes it difficult for the schools to make comprehensive plans for developing their own system. For example, funds up to 50% of equipment cost have been available for UHF between stations under the ETV Facilities Act, but no similar funds are available for ITFS stations. Thus, the schools may be influenced towards some media system by the availability of Federal funds even though the system may not be suitable for their needs. A comprehensive funding program is needed which demands good overall planning and selection of media as a prerequisite to funding.

The FCC is the other agency which directly affects media systems. As discussed earlier, the FCC regulations do not provide for wide area telecasting for instructional purposes which means that there is no economical system for rural areas.

Cost Structure of Instructional Media Systems

Determination of the cost structure of instructional media systems requires the identification of the functional components of the system and the elements of those components. The cost of these elements than can be determined as relevant variables are changed, e.g., number of students, area, etc.

The functional components of instructional media systems were identified as production, distribution and reception. The elements of cost are listed in the body of the report. The functional components are relevant because the costs behave differently for each component as relevant variables are changed over the range of environments. Some of the important relationships which were uncovered are listed in the following paragraphs. All costs discussed are annual equivalent costs per student (annual operating cost plus amortization).

The production cost decreases rapidly as the number of students using the materials is increased. Thus cooperation of several school districts or even a national center for the production and duplication of materials would be extremely desirable.

The distribution cost decreases with the increased density of the student population. Therefore, costs are lower at the city and metropolitan levels than at the state and regional levels. Although student density is high in the local environment, the effect of the small total student population tends to raise distribution costs to their highest levels.

The reception cost is almost constant across the range of environments.

The total cost strongly indicates the importance of the production cost which decreases to its lowest point at the state or regional level. Also, the reception cost becomes relatively more important in the larger environments. Thus, if emphasis is to be placed on one of the functional segments of media, it should probably be on the programming and reception segments rather than on distribution which has been traditionally emphasized. A possible exception may be the dial access system where the distribution costs are a major portion of the total cost.

The choice of instructional media systems is somewhat limited by the size of the school district or districts which are to be served. The local school system has difficulty financing substantial (10% in our model) utilization of any media. The cost of media systems for the larger environments appears reasonable - $10 per student per year for audio-visual systems and $1 - $2 for audio systems.

Multichannel media are necessary to accomplish any substantial educational task and do not entail a great increase over single channel systems in total cost per student.

The total costs increase as media are utilized more than 10% of the students time, but by only a minor amount of absolute dollar cost.

Comparison of Cost of Instructional Media Systems

The third accomplishment of the study is the comparison of the costs of different media systems. The costs comparison is discussed in detail in the Cost Estimates section of the report, but a few general conclusions are mentioned here.

Production costs are higher for audiovisual materials than for audio materials.

Distribution costs are about the same for all media which do not make provision for the selection of materials by teachers. The added flexibility which results when the scheduling is done by the teacher is quite costly. Thus film is more expensive than television except when each school has its own VTR's and tape library. Classroom dial access is more expensive than radio.

Reception costs are only somewhat higher for audiovisual systems than for audio because the cost of teacher training probably does not vary with the type of system.

Total costs of alternative instructional media are often roughly equal if they are separated into audio and audiovisual categories. In choosing a particular media system within these categories, emphasis should be placed on the dimensions of the particular educational problem to be solved.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

Although the scope of this study did not include investigations of media effectiveness and system cost-effectiveness, it is practically impossible to ignore these areas. The following list of recommendations for further research resulted from questions raised during the study concerning problems of effectiveness and their relationship to cost. The ultimate answer to whether an instructional media system is applicable to a specific environment rests in part on solving these problems. These solutions may also provide for substantial breakthroughs in new system designs with potential cost savings and greater cost effectiveness.

1. Probably the most important area is the redefinition of the role of instructional media in the educational process. As long as media are purchased in an ad hoc fashion without sufficient planning, they will continue to be unnecessarily costly and will not be completely effective. (Reference "Selection of a Media System - An Overview," Volume I, page 3.)

2. There has been considerable development of individual instruction in recent years. The instructional media should be rigorously and creatively tested for their applicability to individualized instruction. This offers one of the best opportunities for media to increase the cost effectiveness of education through more effective utilization of teacher time.

3. The concept of media as communication devices to bring a team of resource persons into an individualized program of education for each student should be investigated. The media could function to stimulate and motivate each child through presentations by teachers, psychologists, heros, parents, etc. This approach might have immense value in reaching the presently unreachable students who become an extremely expensive drain on the educational and economic system.

4. Many of the teachers in the United States have not had an opportunity to learn to use the instructional media that are now available. As media are made a more important portion of the educational process, the problems of communicating these innovations to teachers will become more acute. Methods of training teachers to use media should be developed and implemented. The dollar costs of such training would be a significant portion of the budget of an instructional media system, but the costs in terms of decreased effectiveness which result from the lack of training are immense although unmeasurable.

5. The production of instructional media materials is attempted by groups of schools too small to afford a significant effort to develop quality materials. The feasibility of establishing a national system to produce and distribute instructional media materials should be considered. There are, of course, considerable restraints on this type of program. However, a diverse system with adequate safeguards may be possible and also may be many times more effective and less costly than existing individual efforts by single school systems.

6. It may be that existing FCC policies are not designed to encourage cooperation of school systems in the distribution of instructional television and radio materials. A study of the effect which current FCC policies have on these matters would be desirable.

7. The existing copyright laws hinder the most effective use of a flexible multi-media approach. There may be substantial reason to maintain those provisions of the law which seriously affect media use, but measurement of their possible costs in terms of educational loss should be investigated.

8. It is not easy to establish the scope of existing instructional media systems. An attempt ot catalog the inputs and outputs of all systems would make it possible to better assess the current status of instructional media systems and better guide their future development.

BIBLIOGRAPHY

1. Accardo, S. F. Educational Films — Market Environment. General Learning Corporation Internal Report, May 12, 1967.

2. Adelson, M., editor. "Planning Education for the Future: Comments on a Pilot Study," American Behavioral Scientist, March, 1967. pp. 1-31.

3. Advanced System for Communications and Education in National Development, Final Report. Stanford University, School of Engineering, June 1967.

4. "Advanced Concepts Studied by Air Force," Aviation Week and Space Technology, March 16, 1964.

5. Alford ITFS Transmitting Antennas. Winchester, Massachusetts, Alford Manufacturing Company, n. d.

6. Anderson, D. A. The Social Context of Educational Planning. Paris, UNESCO, International Institute for Educational Planning, 1967.

7. The Audio-Visual Equipment Directory. Thirteenth edition, 1967. Fairfax, Virginia, National Audio-Visual Association, Inc. 1967.

8. Balogh, R. L. and Purdum, D. L. Computer Assisted Instruction Feasibility Study. Houston, Philco-Ford Corporation, January, 1968.

9. Barson, J., et al. A Procedural and Cost Analysis Study of Media in Instructional Systems Development. East Lansing, Michigan, Michigan State University, September, 1965.

10. Beeby, C. E. Planning and the Educational Administrator. Paris, UNESCO, International Institute for Educational Planning, 1967.

11. "Behind the Communications Mess," Business Week, November 18, 1967, pp. 66-74.

12. Bloodworth, M., et al. Highlights of Schools Using Educational Media. Washington National Education Association, Department of Audiovisual Instruction, 1967.

13. British Broadcasting Corporation. Educational Television and Radio in Britain. London, British Broadcasting Corporation, 1966.

14. Broadcast Equipment. Cleveland, Gates Radio Company, 1967.

15. Broadcast Equipment. Dallas, Collins Radio Company, 1966.

16. Broadcast Radio-TV Equipment Price List. Camden, Radio Corporation of America, 1967

17. Bronson, F., et al. Standards of Television Transmission, Factors Affecting Microwave Relay and Closed-Circuit Transmission of Educational Materials. Washington, National Association of Educational Broadcasters, June, 1964.

18. Broodus, T., et al. Microwave Communications. Boston, Smith and Welsch, 1961.

19. Brown, G.W., et al. Edunet. New York, J. Wiley and Sons, Inc., 1967.

20. Brown, J.W. and Norber, K.D. Administering Educational Media. New York, McGraw-Hill Book Company, 1965.

21. Bushnell, D.D. The Computer in American Education. New York, J. Wiley and Sons, Inc., 1967.

22. Campion, L.E. and Kelley, C.Y. Studies in the Growth of Instructional Technology, II: A Directory of Closed-Circuit Television Installations in American Education with a Pattern of Growth. Washington; National Education Association, 1963.

23. Carnegie Commission on Educational Television. Public Television, A Program for Action. New York, Harper & Row, 1967.

24. Catalog of Educational Films. Wilmette, Illinois, Encyclopedia Britannica Corporation, 1967.

25. Catalog of Films. Los Angeles, Film Associates, 1967.

26. Check List for Planning Educational Television Stations. Washington, National Education Television and Radio Center, n.d.

27. Christ, C.F. Econometric Models and Methods. New York, John Wiley & Sons, Inc., 1966.

28. Cohen, E. Evaluation of Available Instructional Television Programs. Paper delivered at the Conference on Economics of Educational Television, Brandeis University, May 1963.

29. Coleman, J.S. Innovations in the Structure of Education. Baltimore, The Johns Hopkins University, The Center for the Study of Social Organization of Schools, 1967.

30. "Comments of the National Association of Educational Broadcasters Before the Federal Communications Commission," NAEB Journal, July-August 1967. pp. 26-56.

31. Computers in Higher Education. Report of the President's Science Advisory Committee, February, 1967.

32. Conference on the Impact of Educational Trends. General Learning Corporation Internal Report, September 12, 1967.

33. Conrad, M. J. and Griffith, W. "Organizational Character of Education: Facility and Business Management," Review of Educational Research, October, 1964. pp. 470-484.

34. The Cost Analysis of Dial-Access Information Retrieval Systems for Education. General Learning Corporation Internal Report, May, 1967.

35. "The Cost of Audio-Visual Instruction 1964-65, 1965-66," School Management, June, 1966.

36. Decker, M. T. Airborne Television Coverage in the Presence of Co-Channel Interference. U. S. Department of Commerce, National Bureau of Standards Technical Note 134, January, 1962.

37. Decker, M. T. Service Area of an Airborne Television Station. U. S. Department of Commerce, National Bureau of Standards Technical Note 35, October, 1959.

38. Design for ETV, Planning for Schools with Television. New York, Educational Facilities Laboratories, 1960.

39. Diamond, R. M., editor. A Guide to Instructional Television. New York, McGraw-Hill Book Company, 1964.

40. Digest of Educational Statistics, 1966. U. S. Department of Health, Education, and Welfare, Office of Education, 1966.

41. Directory and Yearbook of Educational Broadcasting. Washington, National Association of Educational Broadcasters, October, 1967.

42. Economic Principles for Pricing Airport Services. South Pasadena, Stanford Research Institute, 1961.

43. Edding, F. Methods of Analyzing Educational Outlay. Paris, UNESCO, International Institute for Educational Planning, 1966.

44. Educasting Systems. New York, TuTorTape Laboratories, Inc., October, 1967.

45. Educational Broadcasting Review. October, December, 1967.

46. Educational Planning: A Bibliography. Paris, UNESCO, International Institute for Educational Planning, 1964.

47. Educational Planning: An Inventory of Major Research Needs. Paris, UNESCO, International Institute for Educational Planning, 1965.

48. "Educational Television," Audiovisual Instruction, November, 1967.

49. Educational Television Distribution. Baltimore, Westinghouse Electric Corporation, Air Arm Division, 1963.

50. Educational Television, The Next Ten Years. U. S. Department of Health, Education and Welfare, Office of Education, 1965.

51. Engineering Aspects of Television Allocations. Television Allocations Study Organization, 1959.

52. Engineering Report to Purdue University on a Television System Study and the Development of a Technical Design Utilizing the Telecommunications Media in Education. Washington, Atlantic Research Corporation, July 15, 1966.

53. Erickson, C. W. H. Administering Audio-Visual Services. New York, The Macmillan Company, 1959.

54. Estimating Cost of a Nationwide Educational System. Cambridge, Arthur D. Little Company, January 25, 1967.

55. Federal Communications Commission. Channels for Television Transmission for Use in Educational Television System, Tariff 253. U. S. Government Printing Office, 1963.

56. Film Catalogue. New York, Modern Learning Aids, 1967.

57. Film Catalogue, 1966-1967. Los Angeles, Churchill Films, 1967.

58. The Financing of Educational Television Stations. Washington, National Association of Educational Broadcasters, n. d.

59. Fink, D. G. Television Engineering Handbook. New York, McGraw-Hill Book Company, Inc., 1957.

60. Finn, J. D., et al. Studies in the Growth of Instructional Technology, I: Audio-Visual Instrumentation for Instruction in Public Schools, 1930-1960, A Basis for Take-Off. Washington, National Education Association, 1962.

61. "Foreign Language Teaching," Audiovisual Instruction, October, 1966.

62. Fulton, W. R. Criteria Relating to Educational Media Programs in Colleges and Universities. Washington, National Education Association, 1966.

63. Godfrey, E. P., et al. Audiovisual Media in the Public Schools, 1961-1964: A Profile of Change. Washington, Bureau of Social Science Research, Inc., December, 1965.

64. Godfrey, E. P. "Changes in AV Resources and Aspirations — 1961-1964," Educational Screen & AV Guide, January, 1966. pp. 18-21.

65. Gordon, G. N. Educational Television. New York, Center for Applied Research In Education, 1965.

66. Gordon, T. J., et al. Report on a Long-Range Forecasting Study. Santa Monica, The Rand Corporation, September, 1964.

67. Gould, M. F. A Study of Student Enrollment and Instructional Costs Based on Teachers' Salaries: Senior High Schools Palo Alto Unified School District. Palo Alto, Palo Alto Unified School District, June, 1966.

68. Governor's Committee. Missouri Educational Television Survey. Jefferson City, State Department of Education, 1962.

69. Green, A. C., editor. Educational Facilities with New Media. Washington, National Education Association, Department of Audiovisual Instruction, 1966.

70. Grobowski, Z. Report to the Nebraska State Committee On Educational Television on an Engineering Survey for Nine-State System of Educational Television Broadcasting. Washington, Jansky & Bailey, 1962.

71. Guidelines for Cost Estimating 2500 mc Instructional TV Systems. Camden, N. H., RCA, n. d.

72. Hamblen, J. W. Education and the Computer — Pluses and Minuses in the Educational Equation. American Management Association Conference Paper, 1967.

73. Hammett & Edison. A Computer Program for Predicting Performance of 2500 MHz Instructional Television Systems. Sacramento, State of California, Department of General Services, April 1, 1967.

74. Hansen, D. and Dick, W. CAI Center — Institute of Human Learning, Semi-Annual Progress Report. Tallahassee, Florida State University, July, 1967.

75. Harbison, F. Educational Planning and the Human Resource Development. Paris, UNESCO, International Institute for Educational Planning, 1967.

76. Hauf, H. D., et al. New Spaces for Learning: Designing College Facilities to Utilize Instructional Aids and Media. Troy, New York, Rensselaer Polytechnic Institute, June, 1966.

77. Hayes, A. S. Lanugage Laboratory Facilities, Technical Guide for the Selection, Purchase, Use, and Maintenance. U. S. Department of Health, Education and Welfare, Office of Education, 1963.

78. Head, H. Engineering Survey for Virginia Advisory Council on Educational Television. Washington, A. D. Ring & Associates, 1962.

79. Herbert, E., editor. "A Special Report on Technology for Education," International Science and Technology, August, 1967. pp. 28-49.

80. Herold, J. "TV Stations Operating Costs," Broadcast News No. 68. Camden, Radio Corporation of America (reprint), n. d.

81. The Hidden Medium: A Status Report on Educational Radio in the United States. New York, Herman W. Land Associated, Inc. April, 1967.

82. Higher Education Media Study. Washington, Association for Higher Education, and the Department of Audiovisual Instruction, National Education Association, February, 1967. (3 volumes)

83. Hope, T.W. "Market Review: Nontheatrical Film and Audio-Visual — 1966," Journal of the Society of Motion Picture and Television Engineers, December, 1967. pp. 1264-1278.

84. Hoving, T. P. Public Television: A Citizen's View, Washington, National Association of Educational Broadcasters, November 7, 1967.

85. "The Instructional Materials Center," Audiovisual Instruction, October, 1967. pp. 786-829.

86. Instructional Television Fixed Service, What It Is . . . How to Plan. Washington National Education Association, 1967.

87. International Institute for Educational Planning, 1963-1967 Progress Report. Paris, UNESCO, International Institute for Educational Planning, 1967.

88. Jackson, P.W. The Teacher and the Machine. Washington, Committee for Economic Development, September, 1966.

89. Jamrich, J.X. To Build or Not To Build, A Report on the Utilization and Planning of Instructional Facilities in Small Colleges. New York, Educational Facilities Laboratories, 1962.

90. Jones, G.M. A Procedural and Cost Analysis Study of Media in Instructional Systems Development. U. S. Department of Health, Education and Welfare, Office of Education, Bureau of Research, September, 1965.

91. Kirby, R. S. Broadcasting Profile. A Briefing to the Secretary of Commerce, 1964.

92. Komoski, P.K. A Demonstration Project of Programmed Television Instruction. New York, Institute of Educational Technology, Teachers College, Columbia University, July, 1966.

93. Kopstein, F. F. and Seidel, R. J. Computer-Administered Instruction Versus Traditionally Administered Instruction: Economics. Washington, The George Washington University, Human Resources Research Office, June, 1967.

94. Lalime, A. Darien Public Schools Instructional Materials Budget Request. Darien Board of Education, January 9, 1968.

95. Laser, M., et al. Television for the California State Colleges. Sacramento, The California State Printing Office, 1963.

96. Leu, D. J. and Featherstone, R. L. Profiles of Significant Schools, Holland High School, Holland, Michigan. New York, Educational Facilities Laboratories, September, 1962.

97. Levin, H. M. "The Coleman Report: What Difference Do Schools Make?", Saturday Review, January 20, 1968. pp. 57-58.

98. Levine, B., et al. Commercial Communications Satellite. Santa Barbara, California, General Electric Company, TEMPO, October, 1960.

99. Lewis, P. "Here are Specifications for Movie, Slide and Filmstrip Projectors," Nation's Schools, 1966. (Reprint).

100. Lynch, J. E., editor. "Radio and Television in the Secondary School," Bulletin of the National Association of Secondary School Principals, October, 1966. pp. 3-216.

101. Mager, R. F. Preparing Instructional Objectives. Palo Alto, Fearon Publishers, 1961.

102. The Market Outlook for Instructional Technology. Boston, Arthur D. Little Company, October, 1966.

103. Mathematical Models in Educational Planning. Washington, Organization for Economic Co-operation and Development, 1967.

104. McGraw-Hill Films For Elementary Grades, Junior/Senior High School & College. New York, McGraw Hill Book Company, 1967

105. McGraw-Hill Filmstrips For Elementary Grades/High School/College. San Francisco, California. McGraw-Hill Book Company, 1967.

106. Meaney, J. W. Televised College Courses. New York, Fund for the Advancement of Education, October, 1962.

107. Methods and Statistical Needs for Educational Planning. Washington, Organization for Economic Co-operation and Development, 1967.

108. Moldstad, J. A. Sources of Information on Educational Media. U. S. Department of Health, Education and Welfare, Office of Education, 1963.

109. Murphy, J. and Gross, R. Learning by Television. New York, Fund for the Advancement of Education, 1966.

110. NAEB Journal. March-August, 1967.

111. The Needs of Education for Television Channel Allocations, A Survey by the National Association of Educational Broadcasters. U. S. Department of Health, Education and Welfare, Office of Education, 1962.

112. New Focus on ETV. New York, Bell Telephone System, November, 1962.

113. New Teaching Aids for the American Classroom. U. S. Department of Health, Education and Welfare, Office of Education and the Institute for Communications Research, Stanford University, 1960.

114. Nichols, H. L., compiler. Guidelines to Audio-Visual Cataloging by Means of Data Processing. Sacramento, State Department of Education, 1966.

115. 1970 Long-Range Planning in School Finance. Washington, National Education Association, Committee on Educational Finance, 1963.

116. The 1968 Catalog of Recorded Television Courses. Lincoln, Nebraska, National Great Plains Instructional Television Library, 1967.

117. Nobels, E. E., et al. "Applications of Airborne Television to Public Education," IRE Transactions on Education, Volume E-4, no. 1, March, 1961.

118. North, S. A Demonstration of the Impact of Certain Instructional Changes on the Attitudes and Practices of Both Student and Faculty. U. S. Department of Health, Education and Welfare, Office of Education, Bureau of Research, 1967.

119. North, S. Mediated Instruction by Remote Access. Oklahoma City, Oklahoma Christian College, n. d.

120. Norton, K. A., et al. The Distribution of the Population in the Continental United States, Canada, and Mexico Within Various Distances from 1361 Television Market Centers. U. S. Department of Commerce, Institute for Telecommunication Sciences and Aeronomy, Environmental Science Services Administration, January 20, 1966.

121. One Week of Educational Television. Bloomington, Indiana, National Center for School and College Television, 1966.

122. Peterson, R. Final Report to the Consolidated University of North Carolina on the Engineering Aspects of Establishing a Statewide Educational Television System for the State of North Carolina. Washington, Jansky & Bailey, 1963.

123. *Planning Schools for Use of Audio-Visual Materials.* Washington, National Education Association, Department of Audiovisual Instruction, July, 1968.

124. Poignant, R. *The Relation of Educational Plans to Economic and Social Planning.* Paris, UNESCO, International Institute for Educational Planning, 1967.

125. *Prepared Transparencies.* P.O. Box 888, Binghamton, New York, United Transparencies Inc. 1967.

126. Press, O., Kentucky authority for ETV, Frankfort. *Letter to M. G. Sovereign.* May 14, 1963.

127. *Procedures for the Evaluation and Selection of Instructional Materials and Equipment.* Rockville, Maryland, Montgomery County Public Schools, 1965.

128. "Projectors — Product Information Supplement #1," *The EPIE Forum,* September, 1967.

129. *Public Broadcasting Act of 1967.* Public Law 90-129. 90th Congress, S. 1160, November 7, 1967.

130. *Public Broadcasting Act of 1967. Hearings, 90th Congress, 1st Session, on H. R. 6736 and S. 1160 and Similar Bills.* July 11-21, 1967. U. S. Government Printing Office, 1967.

131. *Public Broadcasting Act of 1967. Report from the Committee on Commerce to accompany S. 1160.* May 11, 1967. U. S. Government Printing Office, 1967.

132. *Public Broadcasting Act of 1967. Report from Committee on Interstate and Foreign Commerce to accompany H. R. 6736.* August 21, 1967. U. S. Government Printing Office, 1967.

133. *Quantitative Standards for Audiovisual Personnel, Equipment and Materials.* Washington, National Education Association, Department of Audiovisual Instruction, January, 1966.

134. Reed, O., and Renner, J. *A Report to the Superintendent of Public Instruction, State of Illinois on the Engineering Aspects of Establishing a Statewide Educational Television System.* Washington, Jansky & Bailey, 1964.

135. *Report of the Minnesota Inter-Institutional Television Feasibility Study.* Minneapolis, Feasibility Study of Inter-Institutional Television, January, 1967.

136. *Report to the University of Vermont on the Engineering Aspects of Our Educational Television Broadcast System to Serve the State of Vermont.* Washington, Jansky & Bailey, 1962.

137. Rivest, E. L. Instrumentation Systems for Group Instruction. Schenectady, General Electric Company, Research and Development Center, July, 1967.

138. Robinson, E. A. G. and Vaizey, J. E. The Economics of Education. New York, St. Martin's Press, 1966.

139. Rowland, H. S. and Wing, R. L. Federal Aid for Schools 1967-1968 Guide. New York, Macmillan Company, 1967.

140. Schmiat, E. "Project GROW: Practical Computer Assisted Instruction," Journal of the Society of Motion Picture and Television Engineers, September, 1967. pp. 595-597.

141. School Television, Great Cities, 1967. Lincolnwood, Illinois, The Fund for Media Research, 1967.

142. Schramm, W., et al. New Educational Media in Action. Paris, UNESCO, International Institute for Educational Planning, 1967. (3 volumes).

143. Schramm, W., et al. The New Media: Memo to Educational Planners. Paris, UNESCO, International Institute for Educational Planning, 1967.

144. Schwarzwalder, J. A Survey and Report Concerned with the Feasibility of an Educational Television Network for the State of Kansas. Topeka, Committee on Education of the Legislative Council of the State of Kansas, 1960.

145. Selected Statistics of Local School Systems 1964-65. Washington, National Education Association, Research Division, September, 1966.

146. Sovereign, M. G. Comparative Costs of Instructional Television Distribution Systems. Unpublished PhD thesis, Purdue University, 1965.

147. Spring 1967 School Catalog. St.Paul, 3M Company, 1967.

148. Standards for School Media Programs. Chicago, American Library Association, n. d.

149. Standards of Television Transmission, Factors Affecting Microwave Relay and Closed-Circuit Transmission of Educational Materials. Washington, National Association of Educational Broadcasters, June, 1964.

150. Status of Instructional Television. New York, National Instructional Television Library, March, 1964.

151. Sterling Educational Films. New York, Sterling Educational Films, Inc., 1967.

152. Stewart, D. K. The Cost Analysis of Dial Access Information Retrieval Systems for Education. Madison, Wisconsin, University of Wisconsin, n. d.

153. Study Costs of Educational Media Systems and Their Components. General Learning Corporation Internal Report, 1966.

154. Subject Offerings and Enrollments in Public Secondary Schools. U. S. Department of Health, Education and Welfare, Office of Education, 1965.

155. A Suggested Approach for a State-Wide Multi-Channel Closed-Circuit Educational Television System. Richmond, C & P Telephone Company of Virginia, 1963.

156. Summary: Estimate of Minimum Financial Needs of Educational Television. Conference on Economics of Educational Television, Brandeis University, May, 1963.

157. Surmeier, J. J. An Individual System/Organization Cost Model, Volume 1 — Concept and Application. Washington, Research Analysis Corporation, November, 1965.

158. A Survey of Instructional Closed-Circuit Television 1967. Washington, National Education Association, Department of Audiovisual Instruction, 1967.

159. Tape Storage for Language Laboratories and Neumade Film Library Needs. New York, Neumade Products Corporation, 1967.

160. Tary, J., Livingston, T. L., Macken, D. Application of Multiplex Channels on FM and TV Broadcast Stations to Educational Needs. Boulder, Colorado, ESSA Research Laboratories, March, 1968.

161. Telecommunication Science Panel of the Commerce Technical Advisory Board. Electromagnetic Spectrum Utilization, the Silent Crisis. U. S . Department of Commerce, October, 1966.

162. Telecourse Catalog 1967. Bloomington, Indiana, The National Center for School and College Television, 1967.

163. Television Factbook, 1967. Washington, Television Digest, Inc., 1967.

164. Thomas, J. A. Theme: Measurement of Educational Effectiveness, the Economics of Education. American Management Association Conference Paper, August, 1967.

165. Tickton, S. G. The Education Picture 1966-1976. New York, Academy for Educational Development, November, 1966.

166. Torr, D., et al. Trip Report to Stanford University, Brentwood School Project. General Learning Corporation Internal Report, April 19, 1967.

167. The Use of the C-130E in Airborne Transmission of Educational Television EAD 894. Marietta, Georgia, Lockheed Georgia Company, 1964.

168. Vaizey, J. and Chesswa, J. D. The Costing of Educational Plans. Paris, UNESCO, International Institute for Educational Planning, 1967.

169. A Voice From Space. Princeton, New Jersey, Radio Corporation of America, Astro-Electronics Division, May, 1967.

170. Wade, W. L. and Wade, S. E., editors. A Report of the Second National Conference on the Long-Range Financing of Educational Television Stations. Washington, National Association of Educational Broadcasters, May, 1967.

171. Walker, P. A. National Association of Broadcasters Engineering Handbook. New York, McGraw-Hill Book Company, Inc., 1960.

172. Washington County Closed-Circuit Television Report. Washington County, Maryland, 1963.

173. What Everyone Should Know About Financing Our Schools. Washington, National Education Association, 1967.

174. Williams, D. G., and Snyder, L. W. Motion Picture Production Facilities of Selected Colleges and Universities. U. S. Department of Health, Education and Welfare, Office of Education, 1963.

175. Witherspoon, J. P., et al. Educational Communications System: Phase I, II and III. Washington, National Association of Educational Broadcasters, October, 1966.

176. Your Guide to Better ETV. New York, Micro-link Varian, n. d.

GLOSSARY

AIRBORNE TELEVISION	A television system in which the transmitter, antenna, and input equipment are mounted in an aircraft. Transmission from approximately 20,000 feet provides very large coverage patterns.
AUDIO	Of or pertaining to sound. Specifically, a sound recording. Loosely, any part of or all of the complex of sound equipment, facilities, and personnel.
AUDIOACTIVE	Facilities in which students are equipped with headphones, preamplifier, and microphone by means of which the student's voice is amplified and carried simultaneously to his own headphones as he speaks.
AUDIOACTIVE COMPARE	Facilities in which students are equipped with headphones, microphone, and a two-track tape recorder. The student's voice is recorded on the second track for playback and comparison with the voice on the master track.
AUDIOPASSIVE	Listening facilities in which students are equipped with headphones only.
CARREL	A student study station. Unitized desk, table or booth arrangement designed to facilitate effective independent study by students; may include electronic or optical devices for display of information — controlled either by the student or by outside programming sources — such as teaching machines and audio transmission and reception facilities.
CHANNEL	A complete system for transmitting a signal from an input location to an output location.

CLOSED-CIRCUIT TELEVISION	A television system which limits distribution of an image to those receivers which are directly connected to the origination point by coaxial cable or microwave link.
CONDUIT	Rigid or flexible metal pipe or tubing which contains the wires that conduct signals or current.
CONSOLE, TEACHER'S	Instructor's control center in an electronic laboratory where a distribution panel controls the transmission of program signals and may include facilities for two-way communication with individual students or an entire group.
CONTROL CONSOLE	Equipment that incorporates monitors for viewing separate images picked up by various TV cameras in a system, in addition to the switching and other control devices required. When remote controlled cameras are used, special iris, lens focus, and pan-tilt circuits are included.
DIAL ACCESS SYSTEM	A system in which students are able to select and receive stored programs (audio and/or visual) from a location different from that of the receiver. The transmission from the source to the receiver is wholly or in part electronic.
ELECTRONIC LEARNING LABORATORY	Basically, a series of tape recorders, earphones, and microphones, connected by wire to a console where switches permit the instructor to communicate with (1) all students simultaneously, (2) groups of selected students, and (3) one student, individually.

FILMSTRIP	A length of 35mm or 16mm film containing a succession of still pictures intended for projection one at a time as slides are shown. Some filmstrips are equipped with a tape recording that contains not only the narration but also a subsonic signal that activates a solenoid to advance the filmstrip to the next picture on cue.
INSTRUCTIONAL TELEVISION FIXED SERVICE (ITFS)	An allocation of 31 channels in the frequency band between 2500 and 2690 megahertz to be used for educational television services.
HEADPHONE (also called headset)	A device consisting of one or two telephone receivers connected to a headband for individual listening to audio sources such as interconnection circuits. Some headsets are equipped with a small microphone to permit two-way communication.
LANGUAGE LABORATORY	A room equipped for language instruction in which tape recorders, projectors, record players, and other devices are used singly or in combination.
LINE-OF-SIGHT	In television, a term that describes transmission characteristics of microwave frequencies. Such frequencies are usually limited in transmissions range to the radio horizon. Natural or man-made obstructions existing between the sending and receiving positions further limit coverage.
RANDOM ACCESS	The function of a tape playback unit that enables one to go to any storage location at any time and with equal facility and get a piece of information.

RECEIVER (BROADCAST)	Electronic instrument whose antenna intercepts the carrier wave of a radio or television station to which it is tuned, amplifies the signal, and translates the electrical energy into sound and, where applicable, picture.
RECORDER, VIDEO-TAPE	A device to record both the audio and video signals of a television production on a special magnetic tape which can be played back to reproduce the entire program.
SATELLITE TELEVISION	The use of a synchronous man-made satellite equipped to receive, amplify, and re-transmit microwave signals from and to specially adapted transmitters and receivers on the earth.
SIGNAL (BROADCAST)	The waves, impulses, sounds, pictures, etc., tranmitted or received.
STUDENT POSITION or STATION	A desk, table, or booth with equipment that enables the student to receive a program and to react to it.
ULTRA HIGH FREQUENCY (UHF)	Wave lengths reserved for commercial and educational television which lie in the wave bands of 300 to 3000 megahertz.
VIDEO	That component of a television signal that contains the visual information.

APPENDIX

SECTION A

INTRODUCTION

INTRODUCTION

Each of the following five sections contains a description of an instructional media system. The costs associated with each of the components of a system are presented and discussed. Costs are summarized on data sheets which list the costs of production, distribution, and reception for each system relative to each environment. Included on the data sheets are equivalent annual cost figures. These figures were obtained by amortizing the capital costs and adding the results to the annual operating costs. This procedure is discussed in the next section on page . Following the cost data sheets are tables presenting summaries of per student equivalent annual costs.

Instructional Television Media Systems are described first. All components are discussed and their associated costs are presented. Some of the discussions of television system components are also pertinent to other systems. For example, the teacher training discussion is essentially applicable to all other systems. Therefore, only the cost information for these components is included in the other media system descriptions. Components which are discussed in detail in the television section only are:

- Planning
- Training
- Administration
- Research
- Testing and Evaluation
- Related Materials
- Facilities

The costs of these components are included in estimating costs for each system as indicated on the cost data sheets.

The final section of the Appendix is the detailed discussion of cost savings which may be possible through advances in technology.

SECTION B

INSTRUCTIONAL TELEVISION MEDIA SYSTEMS

INSTRUCTIONAL TELEVISION MEDIA SYSTEMS

Instructional television systems are widely used throughout the country. A variety of systems for delivery of instructional television materials is available. UHF broadcasting stations, the instructional television fixed service, airborne telecasting, satellite telecasting, closed-circuit cable and microwave, and the use of video tape recorders in the classroom are discussed in this study.

The production costs are independent of the delivery system. They are discussed in the first section without reference to a particular distribution system. The distribution systems are then discussed individually in detail. The reception costs, which have only minor variations for each distribution system, are discussed by application level, i. e., local school district, city schools, metropolitan area, state, and region. Finally, a variety of costs which apply to several of the categories is discussed, namely the costs of initial planning, administration, research and evaluation, related materials, teacher training, and technical training.

Following the descriptions of production, distribution, and reception costs for all television systems is a set of Cost Data Sheets bringing together the three costs for each system in each application area.

Production of Instructional Material for Television Media Systems

The media systems are useless without materials. Indeed the materials are the most important component of the systems once the role of the system is established. Unfortunately they are also the most difficult part of the study when determining costs.

Programming Costs

The ideal cost figures for materials would be optimum costs determined by comparing the cost of preparation with the degree of learning effectiveness. Methods which permit the necessary degree of precision in measuring effectiveness do not yet exist. Therefore, optimum cost levels for instructional material can not be determined.

Practical alternatives for estimating costs of educational materials would include:

- Statistical measures of actual costs,
- Expert opinion of the cost of "good" quality materials,
- Minimum costs of educational materials, and
- Maximum costs for innovative materials which would make full use of the media's potential.

Each alternative is discussed below.

Statistical Measures of Actual Cost. A sizable volume of cost data has been collected for preparation of video taped lessons. A large portion of this data shows extremely low costs ranging from $100 to $200 per lesson. It should be noted, however, that there is considerable doubt concerning the validity of these cost figures. In one survey, for instance, eight ETV stations reported costs of producing a 1/2 hour lesson at 0-$50 excluding recording and transmission costs. (150) It seems unlikely that any cost of the teacher's time could have been included in this figure. In the same survey more than half of the costs per lesson were less than $200. Hagerstown reports costs of programming of about $160 per hour. (143)

The effect of minimal preparation cost is almost certainly reflected in the quality of most programs. In 1963 the National Instructional Library evaluated 68 courses produced by ETV stations which were made available on video tape to other users through a national library (27). These would be expected to be among the best lesson series. The evaluation can be summarized as:

Characteristic	Evaluation
Teaching technique	Only 1/8 of elementary and 1/4 of high school lessons are "well suited for national distribution."
Subject matter presentation	Rejection of most. 2/3 of elementary courses contained ambiguities or inaccuracies.
Production quality	"Weak."
Engineering	"Generally below acceptable levels."

Current materials are undoubtedly better. But, considering present average costs, only minimal quality material can be provided.

Cost of "Good" Quality Materials. Another type of cost figure which could be used would be an estimate of "good" or "high quality" production. The definition of high quality is difficult. The proposed definition, based on existing conditions, would balance the following considerations.

- Existing facilities, personnel, and method of operation,
- Existing expectations of students, teachers, and administrators in quality of television materials both educational and commercial,
- Existing availability and usefulness of research in learning and instructional materials, and
- Existing funding possibilities.

We would maintain, for example only, that a Federally-supported demonstration of video taped instruction would require about $2,000 per lesson for a series of 75 20-minute lessons as follows.

Teacher (annual salary plus moving expenses)	$ 14,000
Content Specialist (annual salary plus moving expenses)	$ 11,000
Guide Writer 1/2 time	$ 4,500
Measurement & Learning Research Specialist 1/2 time	$ 7,500
Pretesting Expenses	$ 2,500
Course Outline Adivsory Committee (6 people, 10 days expenses)	$ 9,000
Reviewers (2 @ $10/lesson)	$ 1,500
Studio Production (75 @ $1,000 each)	$ 75,000
	$125,000
Overhead (@ 20%)	25,000
	$150,000

The $1,000 per lesson cost for studio production is derived as follows, assuming five series can share one studio.

1 Producer-Director 1/2 time	$ 6,000
4 State, light and camera men 1/5 time	$ 6,000
2 Engineers 1/5 time	$ 3,000
1 Artist 1/5 time	$ 2,000
1 Stage manager 1/5 time	$ 2,000
Heat, light, power 1/5 time	$ 2,500
Video Tape for 75 lessons 2", 15 IPS, boxes	$ 7,000
Props, talent and incidentals @ $150 per lesson	$ 11,500
I. O. Tubes	$ 1,000
Amortization on $300,000 capital 1/5 (20 years on studio, 5 years on equipment)	$ 9,000
	$ 50,000
Overhead at 1/2 (studio operations have high overhead)	25,000
	$ 75,000

Amoritization is on capital equipment assumed as follows:

Studio control, switching and distribution	$ 15,000
VTR and accessories	$ 50,000
3 I.O. cameras, pedestals, and cable	$ 75,000
Test and miscellaneous equipment	$ 16,000
Studio, control room, and auxiliary construction 4,500 sq. feet @ $32/sq. ft. (NAB Handbook)	$144,000
	$300,000

Costs of approximately this level represent high quality programs given the present state of the art of instructional television.

Minimum Costs of Educational Materials. Another type of cost for the study of instructional materials would be the minimum cost of materials. For instructional television this would mean a teacher's salary and a minimally-equipped studio run by high school students. An example of how this might be spent is given below, and is not meant to be a normative statement of cost. This cost would probably rise for the city and larger areas because materials would have to be developed which would be useful to a wider range of students.

Example Minimum Programming Cost

Assume 20 minute lesson, one per day, 5 lessons per week x 36 weeks per year = 180 lessons per year = 60 hours per year. A studio produces five series per year.

Teacher annual rate	$ 8,000
Materials at $10/lesson	1,800
1 Set	200
Producer-Director 1/5 of $10,000	2,000
2 Cameramen 1/5 of $3,000	600
1 Engineer 1/5 of $10,000	2,000
Utilities 1/5 of $2,000	400
Overhead	2,000
Depreciation on $30,000 equipment*	1,000

$$\frac{\$18,000}{60} = \$300/\text{hour}$$

* Depreciation based on 1/5 year usage of 6 year life of $30,000 facility as shown below.

Studio 40' x 20' = 800 sq. ft. @ $20/sq. ft.	$16,000
2 vidicon cameras	4,000
Lighting	1,500
Air-conditioning	2,500
Switching, control, and wiring	6,000
	$30,000

Maximum Costs for Innovative Materials. The last type of cost is for a maximum effort where the only limitation is on ability to assemble and control the resources being used. If the philosophy of production were to make the utmost use of the media's potential, programs would result which have very little similarity to most of those currently produced. For example, most ITV lessons still center on a picture of the teacher. Very seldom is "on location" film used. Black and white is the standard. Animation is seldom seen. A standardized time format is used, and lessons are presented in rigid order. Broadcast media are used for point-to-point communication rather than broadcast to the student's own environment. It is probable that many of the present limitations of instructional television could be overcome if an effort were made to depart from the present repetition of premedia classroom format.

Similarly, there has been considerable progress in learning theory in terms of definition of course and lesson objectives, elicitation of student response, and in measurement techniques. If this knowledge were used as a course was prepared, pretested, and reformulated as necessary, again it is likely that a much more effective lesson or other educational material segment could be designed. The costs of such maximum effort materials would be very high, perhaps $30,000 to $200,000 per 20 minutes. Compared to the $300 minimal and $2,000 state of the art cost figures, these costs seem quite high. But such sums are often spent on network television shows, i.e., $30,000 per 20 minutes, and on television advertisements at $10,000 per minute or $200,000 per 20 minutes. Some experimentation on this level should be attempted. However, the figures are not useful for the major thrust of this portion of the study, which is mainly focused on present systems and present educational patterns.

Prerecorded Materials

Introduction. By recording lessons on video or audio tape, film, or computer program, the lessons can be used repeatedly. Of course, some portions of most topics would begin to become obsolete immediately. It is usually assumed that instructional materials not specifically oriented to current events can be used for roughly three to seven years within a school system. Since recording usually will cost only a very small fraction of the cost of producing the materials, there are considerable savings in recording and reuse. This study allows for these savings by assuming a lesson is used for an average of five years. The production cost figures in the model assume a full year's material is available at the inception of the system. Each year afterwards 1/5 of that cost is spent annually in replacing or updating the materials.

Greater use of materials can also be achieved by making additional copies of the recorded materials and distributing them to other school systems or other instructional media distribution systems. Again, making copies is much cheaper than producing the original material and considerable savings can be achieved. Indeed, if a sufficient supply of original materials were available, a rental or copying figure for production cost would be shown rather than the original cost, much as would be done for textbooks. Unfortunately, there are no sources to supply and distribute the amount of material which has been specified in this study, roughly 10% of student time across a wide spectrum of subjects.

Costs of Prerecorded Materials. Recording of instructional television materials is by video tape recorder (VTR). Because the original recording must be of the highest quality, the recording should be done on a high quality VTR costing $40,000 to $70,000 at a speed of 15 inches per second on tape or about $4 per minute. A VTR operator should be assigned solely to this task since a malfunction will require remaking the lesson.

The duplication of additional copies again is performed on a high quality VTR unless only short-term local use is planned. Each master recording can be used to prepare a number of copies at once, but each copy requires another VTR. Usually copies can be made at 7 1/2 inches per second, cutting the tape cost in half. Tapes can be played or recorded up to 100 times. Copying takes as long as the lesson's playing time plus time for set-up and inspection before and after recording. A rule of thumb figure for duplication cost is $1 per minute, divided into:

Tape (master and copy) amortized over 20 usages	$ .20/min.
Operator time	.07
Operating costs (head repair)	.03
VTR amorization	.70
	$1.00

Availability of Prerecorded Material. The availability of tape recorded instructional television materials is definitely not up to the level needed for the service assumed in this study. Those materials that are available are generally of low quality, as described earlier. There are a few lessons in some subjects at a few grade levels becoming available, but no comprehensive array is currently obtainable. Science and language materials are most readily available. There are virtually no private companies engaged in the production of instructional television materials. Most materials are produced at an ETV station for local use. Some may be obtained from the Great Plains National Instructional Television Library, the National Center for School and College Television, and the Midwest Program on Airborne Television Instruction. The GPNITL has approximately 400 hours of programming for grades 1-8 and 50 hours of high school programming. (116) There is some duplication in these hours and some of the courses are six, seven, and eight years old. The NCSCT has 70 hours for grades 1-6 and 30 hours for 7-12, most of which are relatively new.(162) MPATI has 715 hours of programming for grades 1-12. Most of the MPATI courses are becoming obsolete since they are over five years old. It is obvious that there is less than 1,000 hours of non-duplicated lesson material in existence. Thus, a school system has two sources, GPNITL or MPATI, from which to obtain about one half of the 1,000 hours of material which it is assumed would be needed for 10% use. Since almost all of the instructional materials now in use were produced for local schools, the material is not suitable for use by other schools. Although the situation may improve, the libraries listed above are not engaged in any significant amount of production at the present time. Each acts almost exclusively as a copying and distribution center. The result is that, with only very minor exceptions, there is virtually no production of instructional television materials other than for local use anywhere in the United States. One remedy would be a national programming source.

National Programming Source

Programming of the instructional media, particularly "high quality" programming, is too expensive for the local school districts. In this study, the high quality requirement is for $3,786,250 for television programming. The obvious solution is cooperation among schools in producing the materials in order to reduce the cost per student. Scheduling becomes an increasing problem as more systems with diverse schedules and programming needs are covered by one broadcast. If the local school could obtain programming at minimum cost, greater scheduling flexibility would result.

To provide materials for the local schools at minimum cost would require:

- Vastly increased production of programs designed for national usage,
- A national or regional tape duplication center to provide copies at low cost,
- Vastly increased use of the materials in the schools so that amortization of the original production cost becomes negligible, and
- Freedom of the schools to make unlimited copies, transcriptions, etc., of the materials.

There are a number of problems to be solved before the steps above can be accomplished. One problem is the desire of some people to exclude the Federal Government from the production of educational materials. A continuation and expansion of present funding of production by diverse groups could expand the availability of programming without actual materials production by the Federal Government. Funds could be supplied to:

- Local schools for better programming production in science, etc. just as NDEA funds are used to buy films, etc.,
- Local ETV stations who would act as production centers and coordinators for local schools in their area,
- State departments of education,
- Regional laboratories of OE,
- OEO programs in vocational education,
- Scientific and other interest groups, AACS, etc., and
- Ethnic and cultural groups.

A national duplication facility is available already in limited form. The copyright problem may be substantial but the funding could contain provisions for free use.

The cost of materials to the schools could be reduced almost to the absolute minimum (duplication cost plus tape) of about $100 per hour. The $100 allows for the duplication of the materials at one dollar per minute plus an additional $40 per hour which covers the cost of coordinating shipments with the schools. It is conceivable that standardized reliable small VTR's will lower this cost within a few years. Providing each school system with a permanent copy rather than duplicating and circulating the tapes between the national center and the school might be possible because of the lower cost of tape for the small VTR's.

Combined Programming Costs

Introduction. Tables 1, 2 and 3 show the calculation of the instructional television programming cost for the various size systems used in the study. These calculations are based on the programming costs described above, i.e., high quality, minimum, and cost from a national programming source.

The programming costs are included as one portion of the production category.

The high quality materials are based on $5,000 per hour as suggested in the section above and on a $145 per hour rental figure. Since it is assumed that 1/5 of the materials are replaced each year, a yearly figure is also shown for comparison with the other types of programming. Cost per student is also shown.

The minimum cost is based on the $300 per hour live production figure suggested above and the rental of a fraction of the materials at $145 per hour. As the systems become larger more tapes are needed because of the wider variety of student needs. The proportion of rented films declines as the larger system can more easily afford to develop its own materials.

The costs of the national programming source are based on $100 per hour.

TABLE 1

HIGH QUALITY PRODUCTION COSTS

Application Area	Hours	% Rent	Cost/Hour	Sub. Total	% Produce	Cost/Hour	Sub. Total	Total
Local	1000	1/4	$145	$36,250	3/4	$5,000	$3,750,000	$3,786,250
cost/student								$60.17
City	1200	1/4	145	43,500	3/4	5,000	4,500,000	4,543,500
cost/student								$ 7.22
Metropolitan	1300	1/4	145	47,125	3/4	5,000	4,875,000	4,922,125
cost/student								$ 1.96
State	1500	1/4	145	54,375	3/4	5,000	5,625,000	5,679,375
cost/student								$ 1.35
Region	1600	1/4	145	58,000	3/4	5,000	6,000,000	6,058,000
cost/student								$ .14

Production Assumptions: 1/2 of total hours are 20 min. tapes, 1/2 are 30 min. tapes

Cost of 20 min. tapes is $100 per min.

Cost of 30 min. tapes is $66.67 per min. since most costs are fixed.

Cost per hour = 30 x $100 + 30 x $66.67 = $5,000 per hour.

TABLE 2

MINIMUM PRODUCTION COSTS

Application Area	Hours	% Rent	Cost/Hour	Sub. Total	% Produce	Cost/Hour	Sub. Total	Total
Local	1000	1/2	$145	$72,500	1/2	$300	$150,000	$222,500
cost/student								14.83
City	1200	1/4	145	43,500	3/4	400	360,000	403,500
cost/student								2.69
Metropolitan	1300	1/4	145	47,125	3/4	400	390,000	437,125
cost/student								.78
State	1500	1/4	145	54,375	3/4	500	562,500	616,875
cost/student								.62
Region	1600	1/4	145	58,000	3/4	500	600,000	658,000
cost/student								.07

Assumption: 1/2 of total hours are 20 min. tapes, 1/2 are 30 min. tapes

1000 hours = 2500 tapes (1500 20 min. tapes + 1000 30 min. tapes)

TABLE 3

NATIONAL PROGRAMMING SOURCE PRODUCTION COSTS

Application Area	Hours	@ 100/Hour
Local	1000	$100,000
cost/student		6.67
City	1200	120,000
cost/student		.80
Metropolitan	1300	130,000
cost/student		.22
State	1500	150,000
cost/student		.15
Region	1600	160,000
cost/student		.02

Assumption: 1/2 of total hours are 20 min. tapes, 1/2 are 30 min. tapes

1000 hours = 2500 tapes (1500 20 min. tapes + 1000 30 min. tapes)

Scheduling and Channel Utilization

The number of times a single program or lesson must be repeated over a short period of time depends on the possibility of having all people who require that program in one or more reception areas at the same time. Scheduling all students taking a particular subject to meet one or more days a week at one time is not always possible. The same program (lesson) may have to be repeated at different times or on different days.

It is difficult to make generalizations since so many variables affect the outcome. However, the variables can be separated into two categories to show the gross effect of an increase in a variable on the scheduling problem.

An increase in the following variables tends to complicate the scheduling problem.

- Total number of subject offerings
- Number of subject offerings provided by media (TV) rather than by a teacher
- Ratio of students enrolled in a subject to teachers teaching that particular subject (If class size is not increased.)
- Intensity of media usage (Ratio of media time in a subject to standard instruction in the same subject.)
- Number of school, district, or state boundaries crossed by a media system

An increase in the following variables tends to simplify the scheduling problem.

- Number of rooms equipped with television, film projectors, etc.
- Number of channels available for distribution of programming (television channels)

The complexity of the scheduling problem will determine the number of repeat transmissions necessary to reach an audience. This might be expressed in terms of a "repetition factor" or "repetition multiplier".

Example repetition factor =	1	no repeats
	1.5	50% repeats
	2	100% repeats
	5	400% repeats

The number of unique program hours and the number of repeats determine the total number of hours to be transmitted. This number may be greater than the maximum capability of a single channel.

100% channel utilization = 180 days/year x 5 hour/day = 900 hours/year/channel

Broadcast UHF stations may be able to transmit nearly 100% of scheduled time. (900 hours/year during school hours). However, multichannel systems may share certain equipment and staff, etc., to achieve economies in operation or capital investment. Therefore, all channels of a multichannel system may not be able to transmit 100% of the time.

Factors affecting 100% utilization of a channel are:

- Reliability of equipment,
- Competence of maintenance personnel,
- Availability of test equipment and spare parts,
- Availability of program material (live, tape, film),
- Number of studios for live production,
- Ratio of studio rehearsal time to "on air" time,
- Number of tape playback units or film chains per channel, and
- Other uses for recorders, cameras, playback units, etc., (practice, critique, edit, copy, etc.)

Because of the above factors, it is assumed that a single channel of a multichannel system will operate only about 60% of the time. If 50% of the transmissions are repeat programs, then 1,500 transmission hours are required to provide 1,000 hours of unique programming. The following example illustrates the number of channels required in the system.

$$\frac{1,500 \text{ hours}}{900 \text{ hours/channel} \times 0.6} = 2.8 \text{ channels}$$

Thus, given the above assumptions, a minimum of three channels is required to perform the task. Allowing an extra channel for future expansion brings the number of channels to four.

All the television systems in this report are based on four-channel operation. In some cases, single or dual channel costs are shown to indicate their relation to four-channel operation.

Instructional Television Distribution Systems

In this section the instructional television distribution systems are presented. They are:

- Airborne Television Stations
- UHF Broadcast Stations and Microwave Relay
- Instructional Television Fixed Service
- Closed-Circuit Instructional Television System
- Satellite Television System
- Video Tape Recorder System Network

Airborne Television Stations

Introduction. The concept of airborne television broadcasting was developed and tested shortly after World War II. Instructional materials have been broadcast from aircraft for the last six years under experimental licenses granted to Purdue University and later transferred to the Midwest Program on Airborne Television Instruction, Inc. Lessons are received in most of Indiana and Ohio, roughly a third of Illinois, Michigan, and Kentucky, and a corner of Wisconsin. In this section the equipment, personnel, and supplies required for the airborne broadcasting system will be described and their costs enumerated. The cost figures are largely drawn from the experience of MPATI (146). Where MPATI experience is projected to other areas, studies from additional sources have been utilized.

System Components. An airborne television distribution system consists of three functional components - the aircraft and flight component, the transmission component, and the input system component. The aircraft provides the antenna height needed for wide-scale coverage. The transmitters provide the broadcast signal radiated from the aircraft. The input component provides the instructional material in suitable form for transmission by the transmitter. The equipment, personnel, and other operating costs for each of these three components, together with their respective costs, will be described separately in the following sections.

Aircraft and Flight

Equipment

The ideal aircraft for use as a flying broadcast station would be a slow, high-payload, high-altitude, long-endurance aircraft with good reliability. The slow speed is required to keep the aircraft's turning radius as small as possible. Without a small turning radius, the broadcast signal will not be uniform in direction and strength, and reception difficulties will result. Modern aircraft design has not placed emphasis on slow speed and long endurance, although the development of such an aircraft for use as a flying military command post, or missile-launching platform, has been discussed (4).

The amount of broadcast equipment and the number of channels depend upon the usable payload of the aircraft. Usable payload and endurance time on station both depend on the amount of fuel (in hours) which can be carried to the broadcast altitude. The amount of fuel consumed per hour is a function of the engine characteristics. In theory, the transmission aircraft should have a low specific fuel consumption (s. f. c.), which is defined as the pounds of fuel consumed per unit of power produced. The reciprocating engine has the lowest s. f. c., but unfortunately its s. f. c. increases with increasing altitude due to propeller inefficiency. The jet engine's s. f. c. decreases with altitude. The problem of design of an optimal aircraft would be considerable even if a project to develop the optimal aircraft were to be undertaken. Unless a military need for an aircraft with this design becomes established, one will have to be chosen fron those designed for other purposes because of the design cost.

A review of aircraft available when MPATI began indicated that the DC-6 was the best aircraft primarily because of the reliability of the engines. Now many more types of aircraft with the required payload and altitude capacities are available. Westinghouse conducted a study of the total flight cost per square mile of television coverage for eight aircraft (49). The use of cost per square mile is important because it attempts to take into account the increased area covered by aircraft with higher altitude capabilities. The choice in the Westinghouse study was also the DC-6. The study specified a three-channel broadcast system which weighs 15,000 pounds, the upper limit of the DC-6 payload capacity. For payloads above 15,000 pounds, the C-130 propjet is available.

The DC-6 aircraft was selected for the one and two-channel broadcasting models. The C-130 aircraft was chosen for the four-channel system. The maximum altitude for broadcasting from the DC-6 has been found to be about 23,000 feet. The C-130 would operate at 30,000 feet.

MPATI uses two DC-6's in order to assure a high degree of broadcast reliability. The second aircraft serves as a standby in case of flight or broadcast difficulties, and makes it possible to undertake repair work which could put an aircraft out of service for several days.

Necessary ground support equipment includes hangars, weather radar, ground-to-air communications, and 6,000 feet of runway. In addition, special navigation equipment must be used in the aircraft to maintain accurately the orbit position.

Equipment costs are shown in Table 4. The DC-6 aircraft costs are based on a review of quoted prices and actual sales prices of aircraft during 1967 as reported by Aircraft Exchange and Services, New York. These sources indicate a price of not more than $500,000 per aircraft is applicable. The DC-6 A/B auxiliary equipment costs are based on updated MPATI costs. The C-130 costs are taken from the Lockheed study. The C-130 auxiliary equipment costs are taken from a Lockheed C-130E support proposal to MPATI, (167), submitted with the above study.

Operation and Personnel

Two full flight crews consisting of a captain, copilot, and flight engineer plus a chief pilot are needed. The presence of a chief pilot provides adequate personnel for both the duty aircraft and the standby in the event of sickness of one of the pilots or copilots. Because almost an hour is required to reach the broadcast altitude, the standby DC-6 aircraft must leave the ground as soon as the duty aircraft indicates it will have to begin its half-hour descent. Thus, two full crews are needed to allow departure of the standby aircraft before return of the duty aircraft. Also, the broadcast schedule requires about 400 more flight hours than the 1,000 hours allowed pilots under FAA regulations. One of the pilots is a certified flight engineer in case one of the two regular engineers is not available.

A maintenance crew of 20 persons is necessary as detailed in Table 5. Maintenance is performed on a three-shift basis in order to provide service

TABLE 4

AIRCRAFT AND FLIGHT COMPONENT EQUIPMENT COSTS

ITEM	DC-6 A/B	C-130
Two aircraft	$1,000,000	$5,200,000
Weather radar, communications, and navigation	150,000	100,000
Spare parts	200,000	750,000
Other aircraft equipment	50,000	112,500
Ground support equipment	100,000	300,000
TOTAL FLIGHT EQUIPMENT COST	$1,500,000	$6,462,500

TABLE 5

FLIGHT COMPONENT ANNUAL PERSONNEL COSTS

ITEM	NUMBER	ANNUAL COST
Chief pilot	1	$ 20,000
Captains	2	32,000
Co-pilots	2	22,000
Flight engineers	3	33,000
Pilot training	40 hours	15,000
Maintenance supervisor	1	9,000
Lead mechanics	3	21,000
Mechanics	6	29,000
Inspectors	3	20,000
Cleaners	3	9,300
Storekeepers	3	12,000
Maintenance clerk	1	6,000
Overtime & extra labor	2,860 hours	10,000
Flight operations supervisor	1	10,000
Flight record & operations clerk	2	8,000
Guard	2	6,000
Benefits for above		14,000
TOTAL ANNUAL FLIGHT COMPONENT PERSONNEL COSTS		$276,300

to the duty and standby aircraft and provide for maintenance personnel at take-off time. A flight operations supervisor and three record and flight operation clerks are required for administration and record keeping.

Costs for the aircraft personnel and supplies required as above are listed in Tables 5 and 6. The costs are based largely upon the experience of MPATI during 1961-1967. An extensive study by MPATI of the costs of moving operations to Detroit or Chicago in late 1962 indicated that total flight operating costs, not including administration or hangar space, would not vary more than 10 per cent at other locations. Hangar facilities were found at the other locations so that there was no need for capital funds for hangars.

No charge was included for runway use or landing fees. United States airports do not generally charge aircraft permanently hangared at an airport except through hangar or fuel charges (42).

The above discussion is based primarily on experience with a two-channel operation. One-channel broadcasting would require the same flight operations except that lower fuel consumption would result from the decrease in weight of the single channel transmission equipment. A fuel savings of about $10, 000 would result from a one-channel operation.

The same personnel requirements were assumed for four or six-channel operation of the C-130 aircraft. Outside contract maintenance was doubled to allow for the 8. 4 percent increase in labor hours per flight hour shown in the Lockheed study as quoted from 1960 Air Transportation Association studies (167). Parts and supply costs were doubled to reflect the difference in material costs shown in the ATA figures. The engine overhaul costs were changed to reflect the cost and life of C-130 engine overhaul as given by Lockheed. Fuel costs were reduced to reflect the lower cost of turbine fuel. The hangar rental and maintenance costs were increased to allow for the increased wing span of the C-130. Other costs were assumed to be the same as for the DC-6 operation.

Transmission System

Equipment

The transmission equipment consists of video tape recorders and television transmitters. The video tape recorders are standard machines with only minor changes. The airborne transmitters are specially modified and carefully installed to prevent damage during landing and turbulent weather. In addition, auxiliary equipment including a turbine-powered generator, DC to AC inverters, electronically-controlled and hydraulically-operated retractable antenna mast, cooling system, picture synchronization, and monitoring equipment are required. A complete description of the MPATI system was given by Nobels, et al.(117).

The transmission equipment costs are summarized in Table 7. These costs are based largely on Westinghouse cost estimates and the actual

TABLE 6

FLIGHT COMPONENT ANNUAL SUPPLIES AND MISCELLANEOUS COSTS

ITEM	AMOUNT	COST	CHANGE FOR C-130 OPERATION (Reduction)
Fuel, turbine JP-4	700,000 gals.		$(20,000)
Fuel, grade 115/145	640,000 gals.	$160,000	
Oil	6,000 gals.	8,000	
Crew travel	1 per month	4,000	
Engine overhaul	4	60,000	28,000
Contract maintenance	-	80,000	80,000
Parts & supplies	-	20,000	20,000
Small tools	-	1,200	
Truck, APU, and tug	-	2,400	
Telephone & telegraph	-	1,200	
Freight		5,000	5,000
Legal & professional services		10,000	
Hangar rental	35,000 sq. ft.	70,000	25,000
Hangar maintenance		15,000	5,000
TOTAL FOR 2 & 4 CHANNEL BROADCASTS		$436,800	$143,000
Reduction in gasoline costs for one-channel operation		(10,000)	
TOTAL FOR ONE-CHANNEL BROADCAST		$426,800	

cost of the first two-channel system. Six-channel ITFS frequency airborne transmission equipment, according to Westinghouse estimates, would cost $5.6 million including spares.

Spare parts costs, based on a Westinghouse estimate, do not vary considerably with the number of channels because most spares are interchangeable between channels.

TABLE 7

TRANSMISSION COMPONENT EQUIPMENT COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Two UHF transmission systems	$2,000,000	$2,200,000	$3,000,000
Development	400,000	300,000	1,600,000
Subtotal	$2,400,000	$2,500,000	$4,600,000
Spare parts	140,000	165,000	180,000
Test equipment	75,000	75,000	75,000
TOTAL	$2,615,000	$2,740,000	$4,855,000

Operation and Personnel

In the MPATI two-channel airborne facility, three people operate the airborne transmitters and recorders. One man is chiefly responsible for the two-transmitter control console while the other two primarily operate the video tape recorders. A crew of four, which includes a maintenance specialist, two standby operators, and a supervisor, remains on the ground. The supervisor also serves on standby flight duty.

For a one-channel facility one video tape recorder operator could be eliminated from the duty and standby crews. An additional airborne operator would be needed in a four-channel facility. A storekeeper for electronic and aircraft parts would supply the maintenance force.

Operating costs for the transmitter and associated equipment are shown in Table 8. These costs were based primarily on the 1963-1967 annual contracts between MPATI and Westinghouse Electric Corporation. MPATI has contracted with Westinghouse to provide the transmitter crews since the initiation of broadcasting because of the experimental nature of the program. Substantial cost savings may be realized if transmitter operation personnel were to be employed directly; these savings have not been included in Table 8. Overtime was included in conformance with MPATI experience. Annual insurance costs for the MPATI airborne system are about $1.65 per hundred dollars of valuation for the aircraft and $1.25 per hundred dollars for the

TABLE 8

TRANSMISSION COMPONENT ANNUAL OPERATING COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Transmitter operation:			
Engineers	$ 40,000	$ 40,000	$ 40,000
Technicians	41,250	68,750	91,250
Storekeeper	6,250	6,250	6,250
Overtime	19,000	26,000	41,000
Overhead & margin	17,000	24,000	29,300
	$123,500	$165,000	$207,800
Supplies, parts & repairs	30,000	55,000	65,000
Insurance (aircraft & transmitters)	50,500	52,500	105,000
TOTAL TRANSMITTER OPERATION	$204,000	$272,500	$377,800

transmission equipment. Although some governmental units rely on self-insurance, others carry fire and disaster coverage to assure that funds will be available to replace particular installations. The airborne system includes insurance risks not encountered by the other systems. Therefore, major insurance costs have been included for all systems. Supply costs were estimated from MPATI experience.

Input Component

Equipment

The ground-based input system needed for an airborne station is a tape duplication facility. It provides tape copies for use in the standby aircraft and for the repeat broadcasts in the schedule. The essential item of equipment in tape duplication is the video tape recorder (VTR). Recently, transistorized VTR's and portable VTR's have become available. The airborne system would utilize transistorized recorders but not portable recorders which are not as dependable or accurate as the standard broadcast versions. For a two-channel broadcast facility, three VTR's and auxiliary equipment would be required in the duplication facility. Use of three recorders permits the production of two duplicates at once, a time and equipment-saving method. For a one-channel system, only two recorders would be needed. For a four-channel system, six VTR's are needed.

Table 9 lists the equipment costs for the input systems. Record and playback models of video tape recorders are now available for about $45,000. Switching equipment would allow for making multiple copies.

TABLE 9

INPUT COMPONENT EQUIPMENT COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Video tape recorders	$ 90,000	$135,000	$270,000
Other electronic equipment & installations	15,000	30,000	60,000
Spare parts, supplies and tools	5,000	7,000	10,000
TOTAL	$110,000	$172,000	$340,000

Operation and Personnel

The two-channel facility would require two shifts, each with two video tape recorder operators, one of whom would be a supervising engineer. In addition, a clerk-librarian would be required to keep records and file tapes. Salaries are based on MPATI experience.

One operator per shift plus an engineer and a clerk-librarian would be required for a one-channel facility with two VTR's. Five operators plus an engineer would be required for a four-channel facility.

Table 10 lists the personnel and supply costs for the input facility. The supply costs are based on cost figures from MPATI experience. The tape supply figure was based on a two-week cycle between recordings on any one tape. Two sets of tapes would be required every two years. A one-channel supply would cost $4,200 at 7 1/2 inches per second. The tape costs in Table 10 are derived from this cost and the requirements mentioned.

TABLE 10

INPUT COMPONENT ANNUAL OPERATING COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Video tape recorder operators	$12,000	$18,000	$30,000
Supervisory engineer	9,000	9,000	9,000
Clerk-librarian	4,000	4,000	6,000
Video tape	4,200	8,400	16,800
Tape recorder head repair	4,300	8,600	17,200
Rent & utilities	3,000	4,200	8,400
Supplies	2,500	4,000	8,000
Benefits for personnel	1,770	2,270	3,700
TOTAL	$40,770	$58,470	$99,100

Summary

Tables 11 and 12 summarize the equipment and operating costs of the airborne system including the costs for the aircraft, flight component, transmission system, and input system.

TABLE 11

SUMMARY OF EQUIPMENT COSTS FOR AIRBORNE SYSTEM

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Flight Component			
Table 4	$1,500,000	$1,500,000	$6,462,500
Transmission System			
Table 7	2,615,000	2,740,000	4,855,000
Input System			
Table 9	110,000	172,000	340,000
TOTAL	$4,225,000	$4,412,000	$11,657,500

TABLE 12

SUMMARY OF ANNUAL OPERATING COSTS FOR AIRBORNE SYSTEM

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Flight Components			
Tables 5 and 6	$703,100	$ 713,100	$ 856,100
Transmission System			
Table 8	204,000	272,500	377,800
Input - Table 10	40,770	58,470	99,100
TOTAL OPERATING COSTS	$947,870	$1,044,070	$1,333,000

Applications of Airborne Television

State Application of Airborne Television

The average area of a state in the United States is about 50,000 square miles. An airborne station can cover a circular area of 100,000 to 200,000 square miles but, since no states are circular, there is a considerable waste of coverage when this medium is applied at the state level. The basic costs in Tables 11 and 12 need not be changed if one airborne television station serves a state.

ITEM	ONE CHANNEL	TWO CHANNEL	FOUR CHANNELS
Capital Cost (Table 11)	$4,225,000	$4,412,000	$11,657,500
Operating Cost (Table 12)	947,870	1,044,070	1,333,000

Regional Application

A maximum of eight airborne stations would be needed for the region, as shown in the Westinghouse study Educational Television Distribution which assumed a 20,000 foot operations altitude. This is roughly a quarter of the stations needed to cover the United States, according to the study. Therefore, the region in our model is "average." In addition to the regular costs, transportation of the tapes to the different airports used would be necessary. All tape duplication would be done in one center. This would allow considerable savings in the number of VTR's required. A third shift could be used and the utilization factor increased significantly. Use of commercial freight service would cost about $4,000 per channel to serve four airports which would be necessary in order to allow extra backup and better utilization of equipment and men. The savings are not reflected in the costs except that it will be assumed that the $4,000 per channel for transportation is absorbed in the savings. The only change in costs is the deletion of the development costs for seven of the transmission systems.

ITEM	ONE CHANNEL	TWO CHANNEL	FOUR CHANNELS
Capital Cost	$31,400,000	$33,196,000	$79,916,000
Operating Cost	7,582,960	8,352,560	10,664,000

Forecast of Service and Technological Changes

Improvements in the aircraft flight component are quite possible. These include use of a DC-7 with propjet engines for longer broadcasts and for increased height and coverage. The same advantages would be available from a jet aircraft with a new laminar flow developed for increased loiter capability. Developments in solid-state amplifier and power supplies may present the same benefits by reducing the weight carried by the aircraft.

Color capability could be added at small additional cost when some of the improvements noted above to ease the weight problems are realized. Until that time, implementation of color would be quite costly.

UHF Broadcast Stations and Microwave Relay

Introduction

Broadcast television stations have been used by educators since 1950 to service both schools and the general public in large cities and metropolitan areas. Over 150 stations are now on the air. Commercial broadcasting in the United States makes use of microwave facilities to provide programming to a network of broadcast stations. It is not surprising that educational broadcasters and educators have proposed the same type of system for providing educational television to large areas. In the majority of cases, these proposals have been for state-wide networks for a particular state. Although several states have been making plans since about 1954, actual achievement of a state-wide network has been delayed in many states mostly because of funding requirements. Complete state-wide networks are rare, although the stations in Alabama and Maine reach a large percentage of the population.

Many states have engaged an engineering firm to conduct a feasibility and cost study for a network of interconnected broadcast stations. The engineering studies are a major source of the data used in this section. The applications filed for grants under the Educational Television Facilities Act administered by the United States Department of Health, Education and Welfare are another major source.

System Components

The operation and costs of the broadcast stations with microwave relay network can be separated into three functional components: the broadcast stations, the microwave relay network linking the stations, and the input center. Figure 20 illustrates the relationship of the three components which are discussed individually below.

Broadcast Stations

Equipment

The major requirements of a broadcast station are a tower, a transmitter, and a building to house the transmitter and accessories. The cost of a tower varies almost linearly with height at least up to 1,000 feet. Higher towers give wider coverage at UHF frequencies. Generally, it may be said that a tower will give line of sight coverage within a radius in miles equal to the square root of twice its height in feet.

One tower height and the resulting coverage could have been assumed throughout the study. Unfortunately, if the terrain is irregular, there are many problems when the coverage is calculated using the above formula. Therefore, tower heights from engineering studies were used for some of the environments.

The average cost of a 1,000 foot tower built for a single high-gain UHF antenna would be about $120,000 according to estimates from two of the largest builders. The design of a tower for more than one antenna involves increased

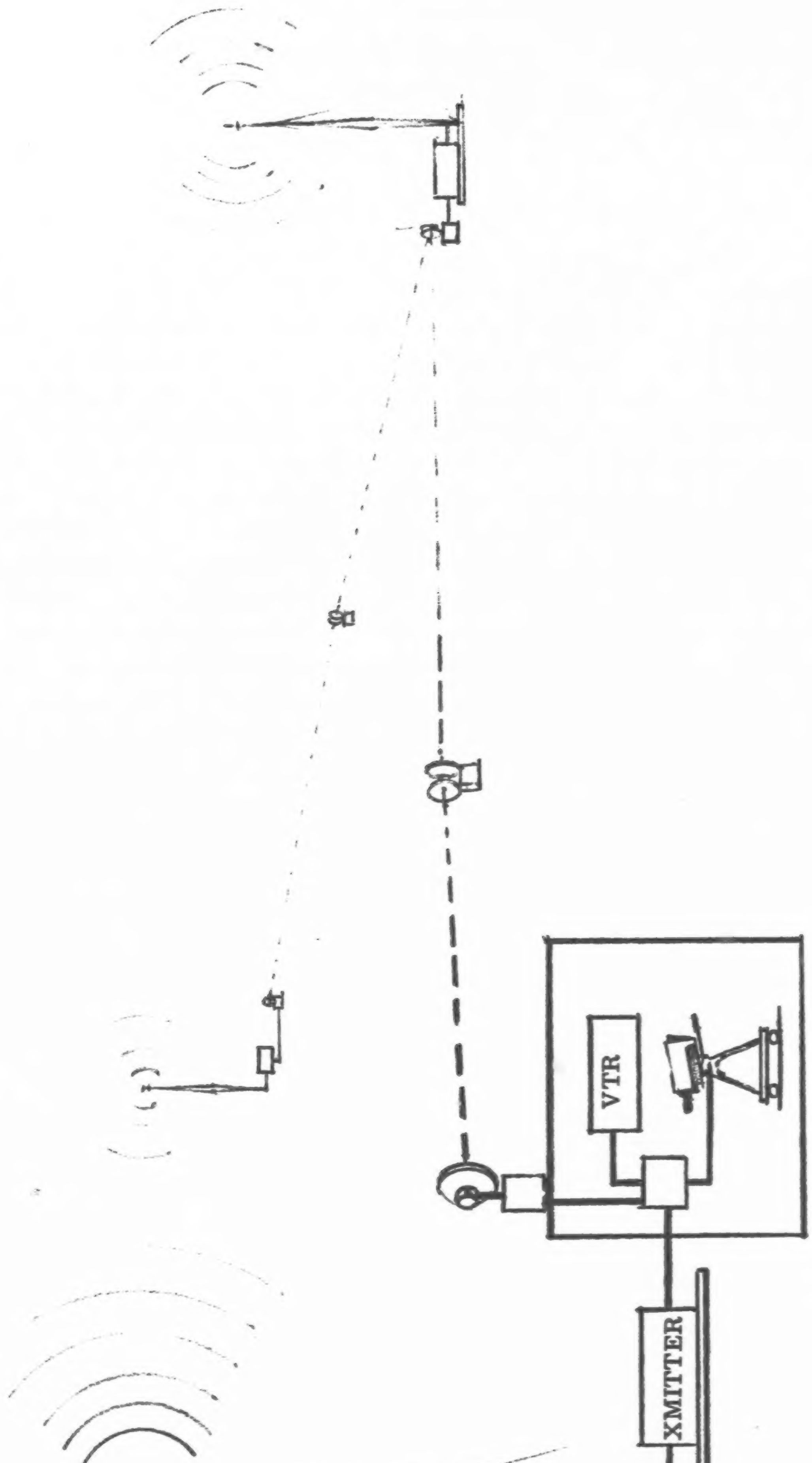

VTR
XMITTER

Figure 20. Microwave Network

wind loads from the antenna, transmission line, and accessories. A table in the NAB Handbook gives increased wind load on a tower from additional equipment (171). A chart in the TASO report gives relative costs of towers for various wind loads (51). The increased cost of towers for multichannel systems was determined from these two sources.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Tower cost	$120,000	$158,000	$216,000
Percent increase	0	32	80

A graph representing the corresponding costs for all other tower heights is shown in Figure 21. The 3 1/8" transmission line specified for UHF transmitters costs $150 per 20 foot section with about 100 feet more than required by the tower height. Installation and accessory equipment adds another $100 per section.

UHF transmitters are specified because only UHF channels are now available in most of the United States except in the Great Plains and Mountain states. Almost all of the engineering studies specified transmitters of at least 10-kilowatt output. Transmitters are available for approximately 2-kilowatt, 10-kilowatt, and 30-kilowatt output from General Electric and RCA, suppliers of the major items of broadcast equipment. The price for the 10-kilowatt transmitter is about $150,000 (16). Since an instructional system serving schools with carefully placed outdoor antennas is being planned, higher power is not necessary. The price of a 2-kilowatt transmitter is $78,500. A set of spare tubes, a control console, and important monitoring equipment are standard accessories purchased with the transmitter at additional cost (16). The antenna with 24-gain specified for the 10-kilowatt transmitters costs about $20,000. An antenna with a gain of 6 for a 2-kilowatt transmitter costs $4,000. In addition, test equipment including an oscilloscope, signal generator, and video sweep generator would be required. A dummy RF load and watt meter are specified for power measurement. Miscellaneous connectors, line pressurization equipment, and other fittings add another $4,000.

A 1,000 foot guyed tower would require approximately eight acres of land. The guy wires are anchored at a distance from the base of the tower ranging from one-half the tower height to the tower height (171). The Kentucky ETV commission estimated a need for about 15 acres per site at $1,000 per acre including land preparation. The Illinois study estimated $1,000 per acre for land alone. Very few of the other studies for proposed systems attempted to estimate land prices because these vary so greatly with location. Preparation of the land also varies considerably. The Kentucky figure of $1,000 per acre corresponds very roughly to the costs of land preparation given in the NAB Handbook, in which preparation costs for one example were $1,600 per acre. A minimum cost of $8,000 is assumed for the eight acres of land. Building requirements are 500 square feet for a transmitter, 240 square feet for a control room, and an estimated 100 square feet for the microwave network equipment. Cost assumed per square foot of building is $21. Building costs are $17,600. Using estimating methods from the NAB Handbook, air-conditioning equipment is computed to cost $6,000. Up to this point, no installation costs have been included except tower,

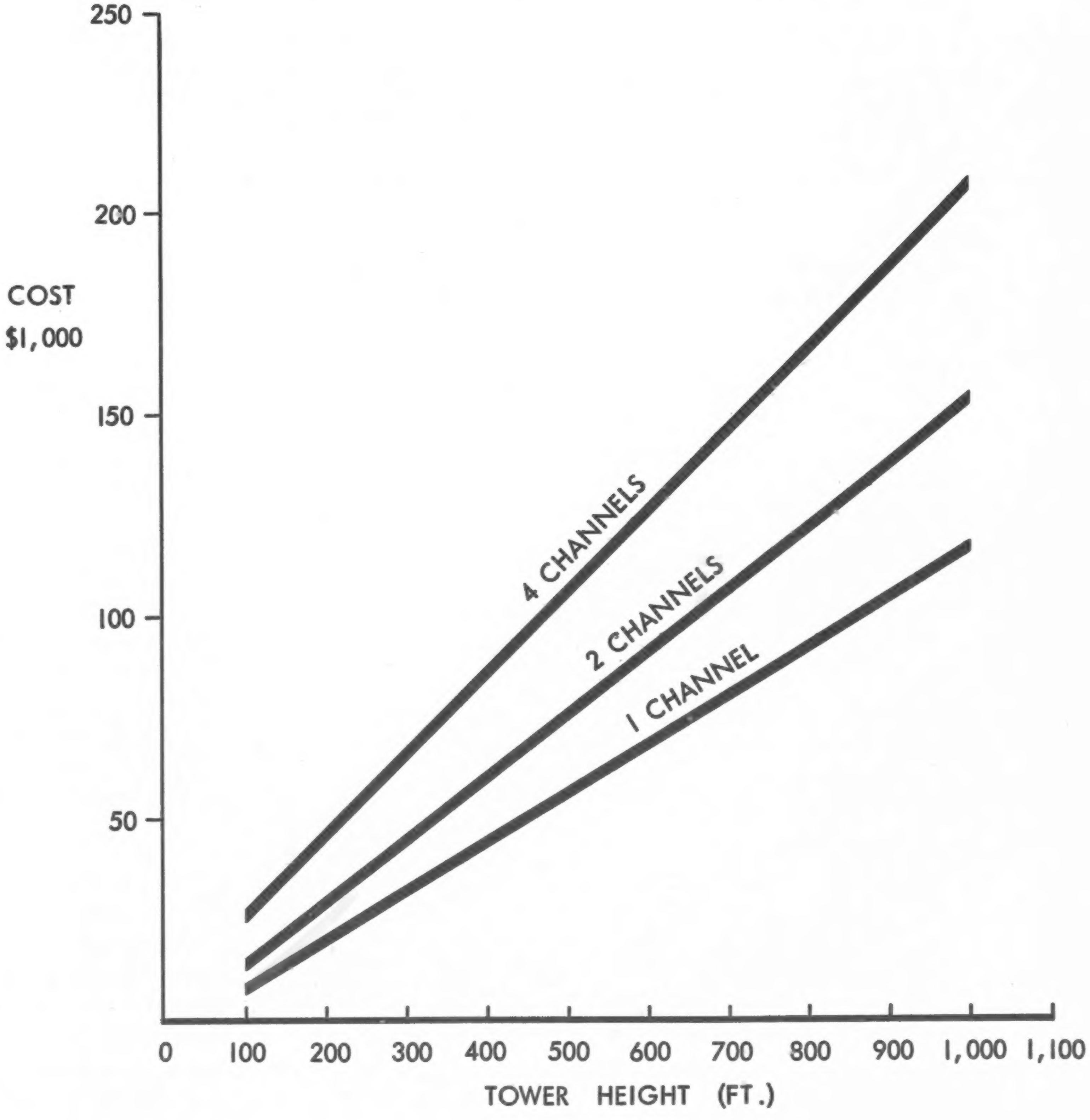


Figure 21. Transmission Tower Costs

antenna, and building costs. Freight is usually paid by the purchaser and is not included except for the tower and building. Legal and engineering fees for the transmitter installations above would be considerable. Sites must be selected, equipment specified, installations inspected, and performance tests made with the help of expert consulting engineers and lawyers. The total estimates for installation, freight, legal, engineering, and contingency fees were usually $20,000 to $30,000 in the engineering studies. The $30,000 figure, about seven per cent of total cost, is assumed to provide adequate coverage for this group of costs.

Table 13 presents a summary of the costs for a single-channel broadcast station as specified above. It also lists the costs for a two-channel, and a four-channel station. Figure 22 presents the same costs in graphical form which allows easier observation of the fixed or variable nature of the cost of each type of equipment. A brief description of the increased equipment needed for additional channels is given below.

Each additional channel requires an additional transmitter. The control consoles and input and monitoring equipment would be consolidated so that one or two operators could run the transmitters. The cost of such a specially-designed master control would undoubtedly be at least as much as the cost of an individual control console plus monitoring equipment since most of this equipment constantly measures or controls the signal of one channel. These items are , therefore, treated as a fully-variable expense. The spare tube sets are reduced by an estimated 25 percent for each additional channel. Such a reduction is possible because a usual stock level of one tube is specified for most of the tubes. This indicates that the necessary stock level is considerably less than one tube per transmitter. One spare tube is specified for installations with a single transmitter because no other source of spares would be available. Other spares are available when there are multiple transmitters at a location.

The cost of towers for the various numbers of channels has already been discussed. Transmission lines would be needed for each channel. The RF load and wattmeter could be used for all the channels. Test equipment would not have to be increased substantially. The land and site improvement would not change, but the building costs would increase with the increased space needed for more transmitters and microwave equipment. Air conditioning costs would also increase. An additional antenna would be needed for each channel unless the signals were multiplexed. A few television installations have multiplexed antennas for two television signals, but this is done only when physical limitations make the use of standard antennas impossible. It was assumed that the cost of a specially-designed multiplexed antenna would be about the same as two standard antennas since the special antenna would have to handle twice the power. Power handling capacity is one of the major reasons for price differences in antennas. Finally, because of the difficulty in estimating the final item of fees, freight, and contingencies, only a small increase of $10,000 is assumed for each system.

The total cost of each one-channel broadcast station is $411,700 as detailed in Table 13. Costs for UHF stations with similar coverages, presented below, were taken from proposals for several state networks.

TABLE 13

BROADCAST STATION EQUIPMENT COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
10 kilowatt transmitter	$150,000	$300,000	$ 600,000
Spare tube set	8,000	14,000	20,000
Control console	7,000	14,000	28,000
Input & monitoring equipment	18,000	36,000	72,000
1,000 foot tower, erected	120,000	158,000	216,000
Antenna & erection	20,000	40,000	80,000
RF load and wattmeter	1,300	1,300	1,300
Transmission line & installation	14,000	28,000	56,000
Line pressurization & miscellaneous equipment	4,000	8,000	16,000
Test equipment	7,800	7,800	7,800
Building, site improvement, land	31,600	51,200	83,500
Installation, etc.	30,000	40,000	50,000
TOTAL FOR ONE STATION WITH 1,000 FT. ANTENNA	$411,700	$698,300	$1,230,600

3

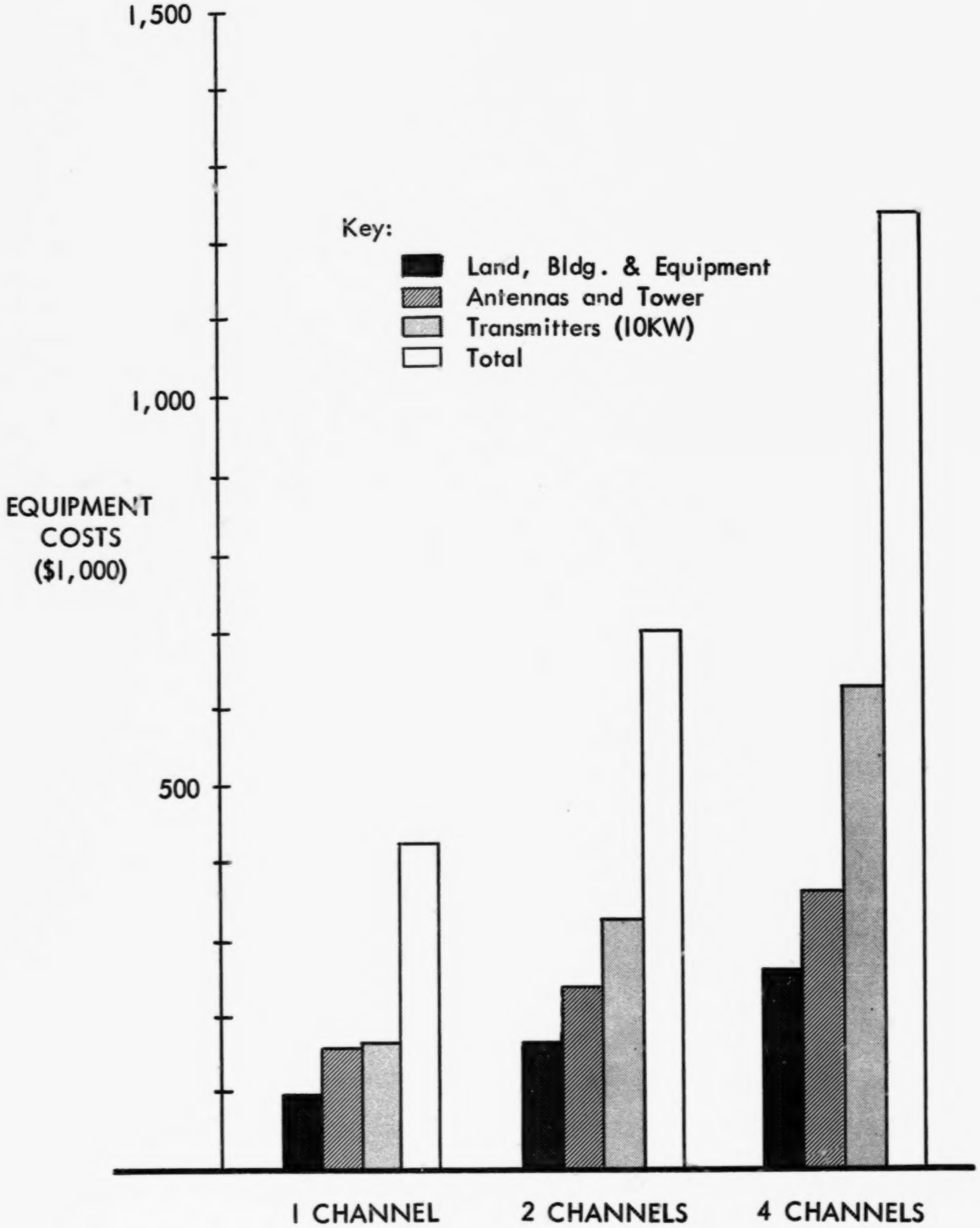


Figure 22. Equipment Costs Per Number of Channels

State	Range or Standard Used	Source
North Carolina	$359,040 to $486,440	133
Vermont	$317,000 to $329,600 (50 ft. tower)	147
Virginia	$351,000 (700 ft. tower, no land cost)	78
Nebraska	$468,480	191
Kentucky	$358,570 to $534,511	136
Illinois	$260,227 to $741,540	145

The cost of a two-channel station is estimated at $698,300. The only available study of a two-channel system quoted $850,000 as the expected average cost for a two-channel UHF broadcasting station with a 1,000 foot tower (68). The cost determined for the four-channel station is $1,230,600.

Operation and Personnel

Operating costs for commercial single channel broadcast stations are well known, but estimating costs for a multichannel instructional system is difficult. Some of the state network studies have explored operating costs. Their results have differed greatly becausethere has been very little experience with stations which operate only from microwave relay without original programming andwhich do not hav a studio as a part of each station. Table 14 lists the estimated operating costs for one station. The costs of primary power, tube, and maintenance parts were given as about $20,000 for one UHF transmitter of 10 kilowatts in the TASO Report. It is assumed that these stations averaged twice as many hours weekly as the instructional system. Therefore, $10,000 would be the cost for these items for each channel. Building maintenance, light, heat, air conditioning, power, telephone, and supplies would require $1,800 yearly. Half of these costs are assumed to vary directly with the number of channels. Maintenance, lighting, and deicer power for the 1,000 foot tower would cost $2,000 yearly. It is assumed that these costs do not increase with additional channels.

At least two qualified operators should be available at each station so that broadcasting can continue if one is unable to work. One operator can service the transmitter or microwave equipment while the other controls transmission. Additional channels require additional operators although the estimated number has been kept to a minimum. For example, only three men are specified for a two-channel station. In comparison, the Missouri study proposed one engineer and three operators for each two-channel station (68). Harold Head recommended four men for a one-channel station without microwave (78). No overtime was included.

Insurance costs for a one-channel station are estimated at $4,930. These estimated rates are taken from one underwriter's rate guide: $1.20 per $100 for the tower, $1.30 for antennas, $.50 for foundations and transmission lines, $.75 for the equipment at the transmitter site. These rates vary according to location and the type of equipment and buildings. The variance, however, is relatively small. The insurance cost of the station will increase with the number of channels as seen on Table 14.

TABLE 14

BROADCAST STATION ANNUAL OPERATING COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Engineers	$ 8,000	$ 8,000	$16,000
Technicians	6,000	12,000	12,000
Power, tubes & repair parts	10,000	20,000	40,000
Building maintenance & utilities	1,800	2,700	4,000
Tower maintenance & utilities	2,000	2,000	2,000
Insurance	3,700	6,300	11,000
TOTAL FOR ONE BROADCAST STATION	$31,500	$51,000	$85,000

Microwave Relay

Equipment

The microwave relay system connecting the broadcast stations consists of a series of relay stations, each equipped with a transmitter and receiver as pictured in Figure 23. Microwave relay transmission is by line of sight techniques and uses low power. Clearance of a circular zone (Fresnel zone) of varying width around the line of sight is required between stations. As a result, microwave stations must be closer together than broadcast stations which can be received out to the radio horizon. An operating interval averaging 30 miles is generally accepted, although in practice each specific path must be plotted and surveyed to determine the feasible path length. Forestation and terrain irregularities affect the average distance. The costs of a simplex (one-way) relay station can be estimated as follows:

Transmitter and receiver	$15,000
Steel equipment	2,000
Two parabolic antennas	3,000
Wave guides and mountings	2,000
Battery power supply	1,000
200 foot tower	24,000
Land and site improvement	5,000
Total for One Relay Station	$52,000

A relay station at a transmitter site, where the building and tower are part of the broadcast system, would cost $37,000. The equipment contemplated for the relay would be of five-watt heterodyne design. A high quality signal would be provided through almost any number of relay stations without degradation since the signal is not demodulated at each station in heterodyning. Equipment which costs under $10,000 for the transmitter and receiver with one-watt power and demodulation at each relay is available and has been suggested for some relay systems. However, the picture quality of such systems over a large number of hops might be impaired.

An additional receiver and transmitter must be added to the system for each additional channel. One antenna can be used for several channels by using multiplex equipment. Battery power and tower costs would remain about the same. Contingency costs, etc. are assumed to increase $1,000 per system. Table 15 summarizes equipment costs per microwave station.

A convenient cost figure is the per mile cost of the equipment needed to connect each broadcast station in a network. Most relay stations have their own towers, but some would utilize the tower of one of the broadcast stations. The study bases the per mile cost on the regular relay station and adjusts for the savings at the terminal as shown in Table 15. Figuring a standard 30 miles per relay results in a cost of $1,733 per mile for equipment.

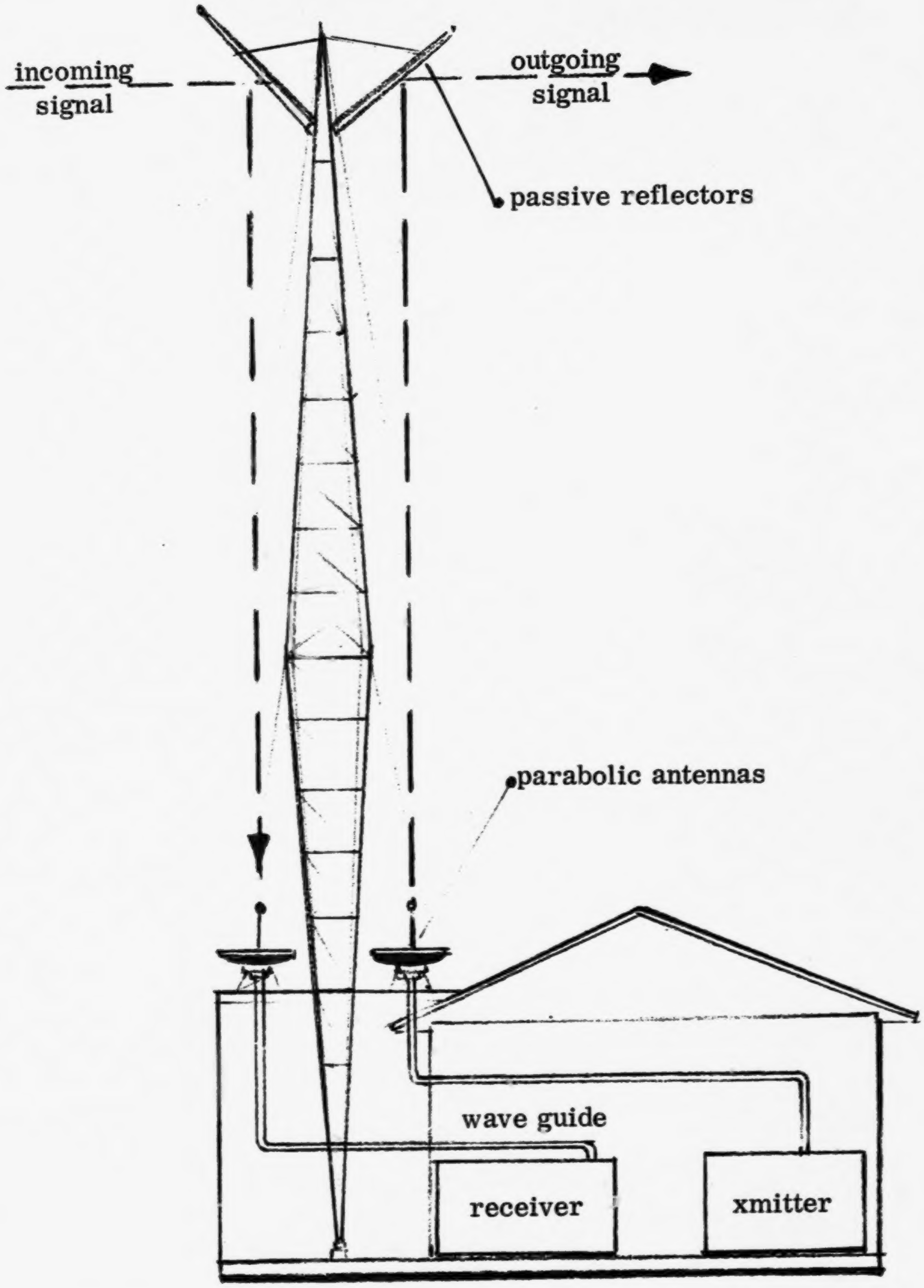

incoming signal
outgoing signal
passive reflectors
parabolic antennas
wave guide
receiver
xmitter

Figure 23. Microwave Relay Station

TABLE 15

MICROWAVE RELAY STATION EQUIPMENT COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Television relay equipment, fault alarm & audio channel	$15,000	$25,000	$45,000
Antennas	3,000	3,000	3,000
Wave guides	2,000	2,000	2,000
Battery power	1,000	2,000	4,000
Building	2,000	3,000	4,000
Tower	24,000	24,000	24,000
Site improvement	3,000	3,000	3,000
Land	2,000	2,000	2,000
Multiplex-filters	0	1,000	1,500
TOTAL FOR ONE RELAY STATION	$52,000	$65,000	$88,500
CAPITAL COST PER MILE OF NETWORK	$ 1,733	$ 2,177	$ 2,950
Adjustment for tower, site improvement, building & land	($31,000)	($32,000)	($33,000)

Operation and Personnel

Cost estimates for the operation of the microwave relay network are difficult to formulate. Few of the engineering surveys reported operating costs in detail. Much of the difficulty arises because personnel can not be assigned to a particular relay station. The relay stations are sufficiently automatic and reliable that teams of maintenance personnel can travel along a considerable portion of the network doing preventive maintenance and responding to emergency breakdowns. The breakdowns are automatically reported by the network's fault-alarm system. In conformance with this concept of maintenance, operating costs are computed on a basis of per mile cost over 30 mile hops. This allows for easy comparison with costs per mile as reported by other sources.

The Kansas survey (144) estimated annual operating costs for the proposed 923 mile network operating 40-50 hours per week. R. Peterson, Jansky and Bailey, (122) estimated annual costs for the proposed North Carolina network of 735 miles.

	Kansas	N. Carolina
Technicians	$24,000	$24,000
Travel	10,900	7,000
Telephone	2,376	-
Power	24,000	9,500
Parts and repairs	20,000	22,000
Total for Network	$81,276	$62,500
Mileage	923	735
Cost per mile	$ 88	$ 85

Harold Head, of A. D. Ring, (78) estimated annual operating costs of a 375 mile network proposed for Virginia at $57,500 or $15,300 per 100 miles.

A study of the actual operating expenses of 11 industrial users of microwave systems shows that they averaged $138 per mile. The 11 systems were for voice communication only and had protection (space) channels available. The instructional television model microwave network specifies no protection channels because it would cost about 1/3 more in initial expense to do so. Without protection channels, when a transmitter or receiver becomes inoperative, some member of the maintenance crew must proceed to that location immediately instead of waiting until the maintenance schedule brings him to the defective facility. This type of operation would increase maintenance costs. The only company in the study which had a television microwave system spent $47 per mile for operation, but the system was only 41 miles long. On the other hand, it was a closed-circuit application which did not demand the high quality adjustment necessary for broadcast purposes. The assumption of a base figure of $10 per mile for operation of a one-channel system is a reasonable approximation. Table 16 gives the operating costs per one mile for one, two, and four channels.

TABLE 16

MICROWAVE RELAY STATION ANNUAL OPERATING COSTS PER MILE OF NETWORK

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Technicians and travel	$ 45	$ 50	$ 60
Power	20	30	50
Parts and repair	35	45	65
TOTAL	$100	$125	$175

The operating costs for the additional channels and shifts are derived from the one-channel costs by analyzing the fixed and variable portions of the operating expenses. It is assumed that the total expense is divided into two groups in order to estimate the parts and repair expense: 1) television relay equipment and 2) tower and other equipment. The operating cost is split in the same proportion as the cost of equipment. The electronic equipment cost is about one-third of the value of each relay station's cost. Therefore, one-third of the operating cost, representing parts and repairs for radio equipment, is assumed to increase directly with usage. Repairs and parts costs for the tower and other equipment are expected to remain constant despite additional channels.

The most difficult estimate to make is the manpower and travel requirement. Where operational difficulties are few, so that maintenance can be performed regularly, an increase in the number of channels will not require much additional manpower. Travel consumes a great portion of the crew's time and no additional travel would be required. If, on the other hand, the crew spends a large part of their time traveling to trouble spots, the increased number of channels would require an increase in the number of crew members. This was one reason why high quality, high power equipment was specified. Consequently, only minimal increases of 10 per cent in manpower and travel are assumed when the number of channels is doubled. Power costs would not increase directly with the number of channels because tower lighting and deicing would be a major part of the power costs, and only one tower is needed at each station.

Input Facility

Equipment

A broadcast station or a network of broadcast stations requires at least one facility to input the programs to be broadcast. In addition, it is desirable to have a communications and control center at the same point if a network is necessary so that supervision of the transmitters and microwave network can be coordinated. The input facilities can be quite complete or minimal. Only the basic transmission equipment, the video tape recorder, and accessories are included here.

Other costs are under the "Production" category. Table 17 presents the basic equipment in addition to the standard transmission equipment. Video tape recorders, to play back only, are available for about $25,000 depending upon accessories. One of these would be required for each channel plus an additional recorder as a spare. The spare would be worthwhile in a network situation because a malfunction in the recorder would deprive one channel of a signal along the entire network. Switching equipment similar to the RCA TS-5A switcher, costing $5,500, is required to coordinate the VTR's and microwave transmitters. An additional 500 square feet of building space is required for each channel for the VTR and tape storage and handling.

TABLE 17

INPUT FACILITY EQUIPMENT COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Video tape recorders	$50,000	$ 75,000	$125,000
Switching equipment	5,500	5,500	11,000
Building costs	10,500	21,000	42,000
TOTAL	$66,000	$101,500	$178,000
If no network is needed, VTR only	$25,000	$ 50,000	$100,000

Operation and Personnel

A VTR operator for each channel and clerk-librarian are needed to operate the center. The network chief engineer would be based at the origination-control station. A control-center operator is required. The operating costs are summarized in Table 18.

TABLE 18

INPUT FACILITY ANNUAL OPERATING COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
VTR operators	$ 5,000	$10,000	$20,000
Clerk-librarian	4,000	4,000	4,000
Control-center operator	8,000	8,000	8,000
Network chief engineer	12,000	12,000	12,000
Supplies	2,500	4,000	7,000
Benefits	3,000	3,400	5,000
TOTAL	$34,500	$41,400	$56,000
Without Network	$12,500	$18,500	$34,000

Summary

Tables 19 and 20 summarize the cost for the broadcast stations and the elements of the microwave relay network.

TABLE 19

SUMMARY OF EQUIPMENT COSTS FOR UHF BROADCAST STATIONS AND MICROWAVE RELAY

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Broadcast station (Table 13)	$411,700	$698,300	$1,230,600
Microwave relay per mile (Table 15)	1,733	2,177	2,950
Input Facility Center (Table 17)	66,000	101,500	178,000
Input Facility without Network (Table 17)	25,000	50,000	100,000

TABLE 20

SUMMARY OF OPERATING COSTS FOR UHF BROADCAST STATIONS AND MICROWAVE RELAY

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Broadcast station (Table 14)	$31,500	$51,000	$85,000
Microwave relay per mile (Table 16)	100	125	175
Input facility (Table 18)	34,500	41,400	56,000
Input facility without network (Table 18)	12,500	18,500	34,000

Forecast of Service and Technological Change

The broadcast stations can be expanded to more channels quite easily. Capital costs can be projected from the chart of cost versus number of channels (Figure 22). Operating costs would change only slightly. Color could be added at simply the cost of color video tape recorders, i.e., an additional $50,000 - $60,000. It is doubtful that the UHF transmission equipment will change drastically in price.

Application of Broadcast Station

Local Level

A tower of 300 feet and two kilowatt transmitter are specified for a local school system. This reduces costs to those shown below. No relay equipment is necessary.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs*			
Transmitter & antenna	$ 84,500	$165,000	$330,000
Tower and line	42,000	59,000	87,000
Other	83,100	183,000	283,000
	$209,600	$407,000	$700,000
Input (Table 19)	66,000	101,500	178,000
	$275,600	$508,500	$878,000
Operating Costs			
Broadcast (Table 20)	$ 31,500	$ 51,000	$ 85,000
Input (Table 20)	12,500	18,500	34,000
	$ 44,000	$ 69,500	$119,000

*Table 13 adapted for 300 foot tower and 2-kilowatt transmitter.

City

A 500 foot tower and 2-kilowatt service are specified for a city system. No relay is needed.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs *			
Transmitter & antenna	$ 84,500	$165,000	$247,000
Tower and line	67,500	94,000	129,500
Other	111,900	190,500	266,800
	$263,900	$449,500	$643,300
Input (Table 19)	66,000	101,500	178,000
	$329,900	$551,000	$821,300
Operating Costs			
Broadcast (Table 20)	$ 31,500	$ 51,000	$ 85,000
Input (Table 20)	12,500	18,500	34,000
	$ 44,000	$ 69,500	$119,000

* Table 13 adapted for 500 foot tower and 2-kilowatt transmitter.

Metropolitan Area

For the metropolitan area coverage, an 800 foot tower and a 10-kilowatt transmitter are specified. This would cover a 40 mile radius if terrain is level. No relay is necessary.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Broadcast*	$384,200	$661,800	$1,170,600
Input (Table 19)	66,000	101,500	178,000
	$450,200	$763,300	$1,348,600
Operating Costs			
Broadcast (Table 20)	$ 31,500	$ 51,000	$ 85,000
Input (Table 20)	12,500	18,500	34,000
	$ 44,000	$ 69,500	$ 119,000

* Table 13 adapted for 800 foot tower.

State Level

The state used for this application has had an engineering survey performed previously which specified the following transmitter power and tower heights.

Power - all but two are 10 kilowatt
Height - ten 100 ft., two 400 ft., two 500 ft., six 700 ft.
The state requires 675 miles of microwave relay.

The costs of facilities of this size using the cost figures from the description are:

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs*			
Tower and line	$ 958,500	$1,337,000	$1,937,000
Transmitter & antenna	1,865,000	3,722,000	7,436,000
Other broadcast	1,762,000	2,942,000	4,092,000
Input and control (Table 19)	66,000	101,500	178,000
Microwave relay (Table 19)	1,170,000	1,470,000	1,990,000
	$5,821,500	$9,572,500	$15,633,000
Operating Costs			
Broadcast (Table 20)	$ 630,000	$1,020,000	$1,700,000
Input (Table 20)	34,500	41,400	141,000
Microwave relay 675 miles (Table 20)	67,500	84,400	118,000
	$ 732,000	$1,145,800	$1,959,000

* Table 13 adapted for various tower heights and transmitter powers.

Regional Level

The number of stations needed to cover a regional area depends upon the topography of the region. This study has relied upon engineering surveys of tower heights performed for states in a region similar to the one hypothesized for this study. These states represent 35% of the total area of the region. The number of stations was projected to 100% coverage of the region giving an estimated 154 stations. A network origination and control center is included as well as microwave relay stations. The microwave network mileage is based on the fact that each station on the average covers an area which has an approximate radius of 30 miles. Therefore, one relay is required between stations, assuming the average spacing. The cost per mile is based on 30 mile hops, and total mileage is estimated to be 9,240 miles. Since approximately half of the relays are located at stations, there is a cost adjustment for the 77 stations which will not need a tower or building.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Broadcast*	$57,600,000	$ 97,500,000	$177,000,000
Input (Table 19)	66,000	101,500	178,000
Microwave relay (Table 19)	13,626,000	17,651,500	24,717,000
	$71,292,000	$115,253,000	$201,895,000
Operating Costs			
Broadcast (Table 20)	$ 4,850,000	$ 7,850,000	$ 13,100,000
Input (Table 20)	34,500	41,400	56,000
Microwave relay (Table 20)	924,000	1,155,000	1,617,000
	$ 5,808,500	$ 9,046,400	$ 14,773,000

* Table 13 adapted.

Instructional Television Fixed Service

Introduction

In 1963 the FCC designed the frequency band from 2500 to 2690 megacycles as the home of the "Instructional Television Fixed Service", a new class of stations to be "operated by an educational organization primarily for the transmission of instructional, cultural, and other types of educational material to one or more fixed receiving locations." "Fixed" means "non-mobile." These stations have the following important characteristics.

- The channels are above the VHF and UHF television receiver channels which are all below 890 megacycles. Therefore, a special converter is required for reception. This does not matter for instructional television because a central distribution converter is used at each school just as it is for UHF or VHF.

- In general, the stations are limited to 10 watts in power and to low transmitting antenna heights. It is assumed in the FCC regulations for the ITFS that interference would not limit the number of stations within an area because transmission would be on a point-to-point basis where necessary. Based on this assumption, up to four channels would be available to any school system.

- Because of the low power output, transmission equipment for this service is cheaper than any available equipment for VHF or UHF broadcasting.

This combination of characteristics is attractive to school systems because ITFS can provide a semi-private, multichannel service to a local school district at a lower initial cost than a VHF or UHF television station. Forty school systems in the nation have ITFS systems on the air and almost 100 others have filed for construction permits.

System Components

Equipment

Each ITFS transmitting system consists primarily of a transmitter, an input device, an antenna, and a small tower. The tower, land, and building are the same as those required for the microwave network stations presented earlier. Assuming a spherical earth, a 200 foot tower theoretically provides line-of-sight transmission to 20 miles although the low power would limit reception to about 10 miles. The tower may also be used for off-the-air relay to another tower in the system. The additional height is necessary so that the signal will clear the ground adequately between the towers.

The costs of ITFS equipment are shown in Table 21. An antenna with gain of 10 is specified for multiplexed use. Wave guide, rather than cable, is suggested to obtain a higher power signal. The cost figures include all the miscellaneous hardware needed for the transmitting system (71).

The ITFS station requires a signal input device just as does the broadcast station. The same costs for input equipment (VTR's) and its operation (one man per channel) are used for both ITFS and broadcast stations with microwave relay network (see Tables 15 and 17). However, in a four-channel facility, a fourth VTR operator is not added since ITFS schedules probably need not be as rigorous.

Operation and Personnel

ITFS stations require at least one operator at each station. The technician operates and maintains the transmitter and the microwave relay equipment. The technician's salary is about $6,000 because a second class operator's license is a prerequisite for adjusting the equipment. Power, supplies, insurance, and parts are estimated at roughly five per cent of the original cost of ITFS equipment. Costs are shown in Table 22.

TABLE 21

ITFS EQUIPMENT COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
ITFS transmitting system	$12,000	$24,000	$48,000
200 foot tower	10,000	10,000	10,000
Antenna	3,500	3,500	3,500
Wave guide 250 feet	1,500	1,500	1,500
Test equipment	6,000	6,000	6,000
Building and land	20,000	20,000	24,000
Installation, etc.	3,000	4,000	5,000
TOTAL EQUIPMENT	$56,000	$69,000	$98,000

Input and relay equipment from Broadcast Tables 12 and 15.

TABLE 22

ITFS ANNUAL OPERATING COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Personnel	$ 6,000	$ 6,000	$ 6,000
ITFS supplies parts power & insurance	2,800	3,400	5,000
TOTAL	$ 8,800	$ 9,400	$11,000
Input Facility*			
With network	$34,500	$41,400	$56,000
Without network	12,500	18,500	29,000

* Adapted from Table 18.

Application of ITFS

Local Level

The local school system requires a transmitting facility and an input facility without a network. The facility could serve all of the district's schools within approximately a 10 mile radius of the transmitter.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Transmission (Table 21)	$56,000	$ 69,000	$ 98,000
Input (Table 17)	25,000	50,000	100,000
	$81,000	$119,000	$198,000
Operating Costs			
Transmission (Table 22)	$ 8,800	$ 9,400	$ 11,000
Input (Table 22)	12,500	18,500	29,000
	$21,300	$ 27,900	$ 40,000

City School System

The city school system can probably find a location from which it can reach all schools with ITFS transmissions. Therefore, its costs distribution would be the same as for the local system (see above).

Metropolitan Level

In order to cover a metropolitan area of approximately 1,500 square miles, about five ITFS stations are required. It is possible to connect these by off-the-air pickup so that only one input facility is needed although separate facilities might be desirable.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
5 ITFS stations (Table 21)	$280,000	$345,000	$490,000
Input Facility (Table 17)	25,000	50,000	100,000
	$305,000	$395,000	$590,000
Operating Costs			
5 ITFS stations (Table 22)	$ 44,000	$ 47,000	$ 55,000
Input facility (Table 22)	12,500	18,500	29,000
	$ 56,500	$ 65,500	$ 84,000

State Level

The state-wide network consists of approximately 130 ITFS stations. There are about 130 school systems in the state, and about the same number of circles with a 10 mile radius cover the state. In densly populated areas, school systems will have to share one station. ITFS systems operating in the same area must be careful to eliminate interference through the use of directional antennas.

There is presently no allocation scheme for the location of ITFS stations. The 130 stations might be able to operate within FCC regulations, but technically it is probably impractical. In Southern California and Clevelend it will become virtually impossible for even a small number of interested systems to operate because of interference. (73).

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Transmission & Input	$10,500,000	$14,700,000	$25,800,000
Operating Costs			
Transmission & Input	$ 2,770,000	$ 3,630,000	$ 5,200,000

New Higher-Powered ITFS

Introduction

As the ITFS system costs were applied to the various levels, it became obvious that total costs for the city or metropolitan area are in line with other media costs. However, the costs were quite high at the local, state, and regional levels. The problem at the local level is that the programming and distribution costs are not spread over enough students. Some of the same problems arise at the state and regional levels because it has been assumed that the stations are not interconnected so that they are unable to share programming costs. One method of overcoming the problem would be to interconnect the stations by microwave or some other means. But since the ITFS was designed as a local service, there are many, many stations to connect and the interconnection cost becomes as large as the other hardware costs. Moreover, the electronic coexistence of a great many local ITFS systems is very doubtful.

The above analysis and the fact that broadcast stations, even with more expensive equipment, can economically cover the state and regional levels, point to the desirability of an extension of the ITFS concept to a higher-powered, wide-area service. This would require a change in the FCC regulations which limit ITFS power to 10 watts.

Equipment

Standard calculations for microwave service indicate that a transmitter of about 200 watts and a 1,200 foot tower can provide line-of-sight service to a 50 mile radius. Line-of-sight conditions would be obtained by using reception towers where necessary because of terrain difficulties. The coverage of a state with four channels could be accomplished within 20 ITFS or UHF channels as suggested by the Georgia State Board of Education in FCC Dockett 14229. This would leave 12 channels which could be made into six bands of two channels each. Since the state system would supply four-channel service, the schools would receive more service even though they could control only two channels. The two channels could be used for scheduling repeats or for local programming.

The equipment for a 200 watt or larger transmitter would have to be developed, but there is similar equipment available in the form of 100 and 1,000 watt UHF translators or microwave transmitters of a lower power at about the same frequency. One thousand watt UHF television translators are now available for $30,000. It is assumed that a 200 watt ITFS transmitter could be manufactured for about the same price.

The other equipment needed is almost the same as for the UHF broadcast stations. Antennas with gain of 40 are available for $11,000. Wave guide would be used to limit power losses. The tower, land, and installation costs are adapted from the figures in the descriptions of the broadcast stations.

Operation and Personnel

The operating costs for the higher-powered ITFS would be about the same as for the other ITFS stations except for increased tower maintenance and the addition of a second operator to improve the reliability of operation. Operating costs are shown in Table 23.

TABLE 23

NEW HIGHER-POWERED ITFS EQUIPMENT AND OPERATING COSTS

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Cost			
200 watt transmitter	$ 30,000	$ 60,000	$120,000
Test and control	10,000	11,000	12,000
Tower	140,000	190,000	280,000
Wave guide 1,300 ft. @ $6/ft.	7,800	7,800	7,800
Antenna	$255,400	$385,000	$601,300
Mixer		3,000	4,000
Land and site improvement	31,600	51,200	83,500
Installation	20,000	30,000	40,000
TOTAL	$255,400	$385,000	$601,300
Operating Cost			
2 Operators	$ 13,000	$ 13,000	$ 13,000
Power & supplies	3,000	3,800	5,000
Tower maintenance	2,000	2,000	2,000
TOTAL	$ 18,000	$ 18,800	$ 20,000

Application of New Higher-Powered ITFS

State Level

About six stations for the state-wide application of new higher-powered ITFS would be required. Microwave relay would be used to tie the stations together with 100 miles between each station. An input facility would be required as it is for the broadcast stations.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Transmitters & towers (Table 23)	$1,532,400	$2,310,000	$3,607,800
Input facility (Table 17)	66,000	101,500	178,000
Microwave, 500 miles (Table 15)	680,500	896,500	1,277,000
TOTAL	$2,278,900	$3,308,000	$5,057,800
Operating Costs			
Transmitters & towers (Table 23)	$ 108,000	$ 112,800	$ 120,000
Input facility (Table 18)	34,500	41,400	56,000
Microwave 500 miles (Table 16)	50,000	62,500	87,500
TOTAL	$ 192,500	$ 216,700	$ 263,500

Regional Level

Approximately 73 stations would be needed for the regional application of the new higher-powered ITFS. About 8,000 miles of microwave network would be used to connect them. At least one input facility should be available.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Transmitter & towers (Table 23)	$18,615,000	$28,105,000	$43,894,900
Input facility (Table 17)	66,000	101,500	178,000
Microwave network (Table 15)	11,601,000	15,080,000	21,191,000
TOTAL	$30,282,000	$43,286,500	$65,263,900
Operating Costs			
Transmitters & towers (Table 23)	$ 1,314,000	$ 1,372,400	$ 1,460,000
Input facility (Table 18)	34,500	41,400	56,000
Microwave (Table 16)	800,000	1,000,000	1,400,000
TOTAL	$ 2,148,500	$ 2,413,800	$ 2,916,000

Closed-Circuit Instructional Television System

Introduction. An alternative to broadcast methods of distributing televised materials is the use of microwave relay stations and cable as a closed-circuit television distribution system. Closed-circuit systems were used for some of the first instructional experimentation with television. The experiments started within colleges and universities where broadcast facilities were not needed because of the concentrated audience. Notable pioneer closed-circuit systems for in-school use are in operation in the Anaheim, California, Washington County, Maryland, and South Carolina school systems.

Because microwave transmission is point-to-point, many closed-circuit systems can be operated in close proximity to one another. There is almost no limit on the possible number of channels in a closed-circuit system. In practice, however, instructional closed-circuit systems currently in use have employed only a limited number of channels.

In theory, a school system or group of systems could build its own closed-circuit network. In practice the construction, operation, and maintenance of in-school, closed-circuit systems are usually handled by the telephone companies, primarily the Bell system. The domination of the telephone companies in the closed-circuit field results from:

- The unwillingness of school systems to make the very large investment in equipment which is needed for a closed-circuit system,
- The telephone companies' proven abilities in installation and maintenance of similar equipment, and
- The FCC's limitations on the use of the microwave spectrum by other than common carriers.

Equipment. A closed-circuit television system consists of microwave relay facilities for the longer distances and networks of coaxial cable for local distribution. The microwave facilities between telephone exchanges may be similar to those outlined in the broadcast station section or they may be part of a higher-capacity system providing telephone or commercial television relay services. The local distribution system consists of a special coaxial cable network with amplifiers at roughly 3,200 foot distances strung on existing telephone poles. The telephone company also provides the distribution wiring and outlets within the school and converters when necessary. Bell system ETV service includes up to six channels, three of which may be standard television channels that would not require frequency converters at the school. The telephone companies provide complete service on a 24 hour per day basis.

Charges. The Bell system has a tariff for ETV service which is lower than its $40 per mile commercial television relay tariff because a simplified cable system is used for ETV. This may mean that the quality of service is not as high. The Bell ETV tariff varies somewhat from state to state but generally follows the schedule which is on file with the FCC.

	Inter-City (Inter-Exchange) (Microwave) Service Per Mile Per Month	Local Service (Intra-Exchange) (Cable) Per Quarter Mile Per Month
First Channel	$27.50	$15.00
Second Channel	12.50	5.00
Third Channel	12.50	3.00
Fourth Channel	10.00	3.00
Fifth Channel	10.00	2.00
Sixth Channel	-	2.00

In addition, there are charges for outputs and the distribution system at the school. For example, the monthly school charges of the Chesapeake and Potomac Telephone Company are $1.25 per outlet, $15 per school for distribution amplifiers, and $7.50 per school for the first channel plus $5 for each additional channel for output equipment. The school charges for distribution are disregarded in the cost comparison because they are offset by the costs of antenna and distribution systems within the school in all of the broadcast systems.

TABLE 24

ANNUAL CLOSED-CIRCUIT RATES

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Network rates/mile			
Inter-exchange	$330	$480	$ 750
Intra-exchange	720	960	1,248
School output	90	150	270

Mileage Estimation. With the rates established as above, the comparison of the cost of a closed-circuit system leased from the Bell system and the cost of broadcast instructional systems depend upon the mileage between schools. Essentially the problem is estimating the length of a line connecting a given number of points (schools) in a given area which, in turn, depends upon the distribution of the points within the area. As a first approximation, the points can be assumed to be uniformly dispersed in a triangular lattice as shown in Figure 24. An adjustment factor, based on mileage surveys of particular states, can compensate for this approximation. The connecting distance for any area containing a given number of schools can be derived using the pattern in Figure 24. (See Closed-Circuit Mileage Model page 138.)

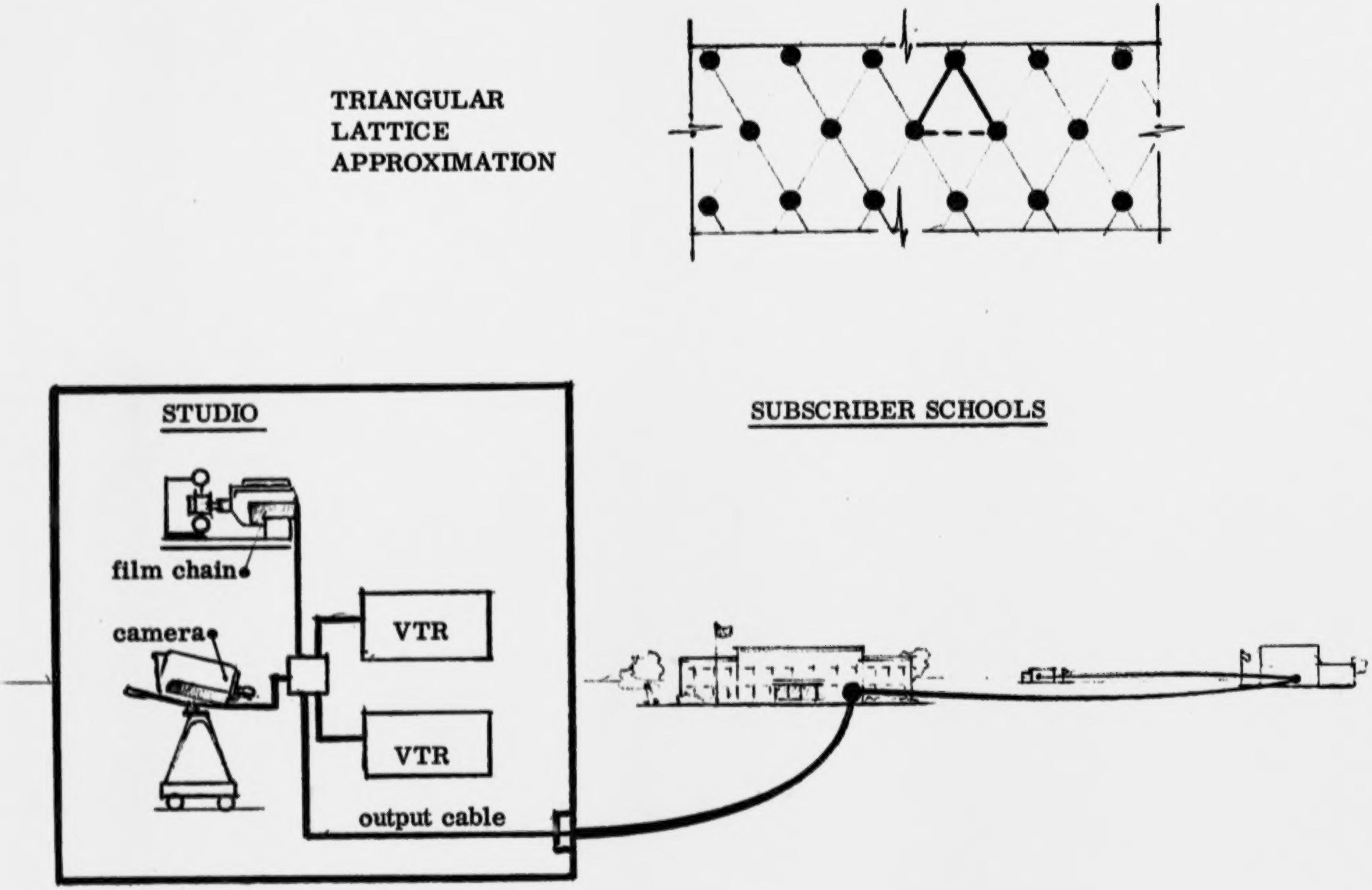

TRIANGULAR
LATTICE
APPROXIMATION
STUDIO
SUBSCRIBER SCHOOLS
film chain
camera
VTR
VTR
output cable

Figure 24. Closed-Circuit Network

Application of Closed-Circuit Network

Local Level

The closed-circuit network for the model local school district requires 26 miles of cable (80 square miles) and 18 outputs, one for each school. It also has an input facility which would be the same as for ITFS or broadcast stations.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Input facility(Table 17)	$25,000	$50,000	$100,000
Operating Cost			
Cable rental (Table 24)	$18,720	$24,960	$32,450
Output charge (Table 24)	1,620	2,700	4,860
Input facility (Table 18)	34,500	41,400	56,000
TOTAL	$54,840	$69,060	$93,310

Large City School System

The closed-circuit network for the large city school system requires 78.5 miles of cable and 182 output rentals, one per school. An input facility also is used.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Costs			
Input facility (Table 17)	$ 66,000	$101,000	$178,000
Operating Costs			
Cable rental (Table 24)	$ 56,520	$ 75,360	$ 97,970
Output charge (Table 24)	16,380	27,300	49,140
Input facility (Table 18)	34,500	41,400	56,000
TOTAL	$107,400	$144,060	$203,110

Metropolitan Area

The closed-circuit system for a metropolitan area requires 720 miles of cable and 729 outputs, one per school. An input facility is required.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Cost			
Input facility(Table 17)	$ 66,000	$101,500	$ 178,000
Operating Costs			
Cable rental	$518,400	$691,200	$ 898,560
Output charges (Table 24)	65,610	109,350	196,830
Input facility (Table 18)	34,500	41,400	56,000
TOTAL	$618,510	$841,950	$1,151,390

State Level

The closed-circuit network requires 4,450 miles of connection and 1,230 output charges. An input facility also is needed. It is assumed that 23% of the mileage is at inter-exchange rates, based on two state surveys and the Virginia high school survey done by the Chesapeake and Potomac Telephone Company.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Cost			
Input facility (Table 17)	$ 66,000	$ 101,500	$ 178,000
Operating Costs			
Cable rental (Table 24)			
Inter-exchange	$ 337,920	$ 491,520	$ 768,000
Intra-exchange	2,466,720	3,288,960	4,275,648
Output Charges (Table 24)	110,700	184,500	332,100
Input facility (Table 17)	34,500	41,400	56,000
TOTAL	$2,949,840	$4,006,380	$5,431,748

Regional Level

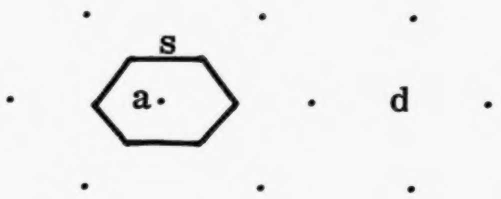
The regional closed-circuit network requires 57,700 units of connection with 13,300 miles of inter-exchange (microwave) and 44,200 miles of intra-exchange (cable). About 12,300 outputs for schools are needed. An input facility furnishes the signal as in the UHF broadcast system.

ITEM	ONE CHANNEL	TWO CHANNELS	FOUR CHANNELS
Capital Cost			
Input facility (Table 17)	$ 66,000	$ 101,500	$ 178,000
Operating Costs			
Cable rental (Table 24)			
Inter-exchange	4,389,000	6,384,000	9,975,000
Intra-exchange	31,824,000	42,432,000	55,161,600
Output charges (Table 24)	1,107,000	1,845,000	3,321,000
Input facility (Table 18)	34,500	41,400	56,000
TOTAL	$37,354,500	$50,702,400	$68,513,600

Closed-Circuit Mileage Model

Given: Area of A square miles containing N schools

Find: The minimum connecting mileage on a per square mile basis, m.



Assume that the schools are distributed in an equilateral triangular lattice as shown in the above figure.

Let a = area served by each school.

s = length of a side of hexagonal area served by a school.
n = minimum number of links connecting N schools in a line.
d = nearest neighbor distance, a crystallographic term for the nearest points in the lattice.

The length of the connecting line will be minimal if both the number of linkages and the distance between points linked in the lattice are minimal. Then it must be true that since d is the shortest linkage possible

$$m = \frac{nd}{A} . \qquad (1)$$

The minimum connecting linkage of N points is

$$n = N - 1 \qquad (2)$$

and for an area as large as a state

$$n = N \qquad (3)$$

approximately.

For a hexagon,

$$a = 2.6s^2 \qquad (4)$$

and solving for s yields,

$$S = .62(a)^{1/2}. \qquad (5)$$

Also,

$$d = 2s \text{ sn } 60^{\circ} = 1.73s \qquad (6)$$

and on the average,

$$a = \frac{A}{N}. \qquad (7)$$

Substituting (5) and then (7) into (6) gives,

$$d = 1.07 \left(\frac{A}{N}\right)^{1/2} \qquad (8)$$

and substituting (3) and (8) into (1) yields,

$$m = \frac{1.07N\,(A)^{1/2}}{(N)^{1/2}\,A} \qquad (9)$$

$$m = 1.07 \left(\frac{N}{A}\right)^{1/2} \qquad (10)$$

Example: The state of Illinois is known to contain approximately 4,600 schools within an area of 55,930 miles. Assuming that the schools are in an equilateral triangular pattern, the minimum connecting distance is:

$$m = 1.07 \left(\frac{4,600}{55,930}\right)^{1/2}$$

m = .287 miles of connecting linkage per square mile in the state.

Note that N-1 closely approximates N.

Studies were available from the Bell systems for two state-wide closed-circuit networks which estimated mileage based on surveys of the state. The results are reproduced in the following chart. In addition, the calculated mileage, based on the above formula, is shown.

	Missouri	South Carolina
Total number of schools	2,082	1,623
Inter-exchange mileage	1,700	1,225
Intra-exchange mileage	6,000	4,000
Total Survey Mileage	7,700	5,225
Area of state	69,138	30,372
Connecting survey mileage per square mile	.1111	.1724
Calculated mileage per square mile	.1855	.248
Adjustment factor = $\frac{\text{survey mileage}}{\text{calculated mileage}}$	.60	.69

The relationship between the survey of connecting mileage and the calculated mileage is fairly consistent. The two adjustment factors differ by only 15 per cent.

The magnitude of the pattern adjustment factor may vary with the type of population distribution. For example, both of the states for which studies are available have large rural areas. The pattern adjustment factor is fractional because schools tend to be clustered in population centers. Since they are clustered, the distance between them is less than calculated when assuming a uniform pattern.

Satellite Television System

Introduction

The number of possible television satellite system configurations is large. Many of the existing studies of television satellite systems are of configurations which are not completely applicable to the task specified in this study. Therefore, a system will be described which will meet the requirements placed upon the other regional television systems discussed.

Equipment

The cost of the other television systems in this report are based on present equipment costs. Since the satellite system would require a longer lead time, its equipment costs are based on extrapolations of the state-of-the-art into 1973. It is also assumed that a common design would be used for all reception equipment and there would be some form of central purchasing. These assumptions tend to reduce some equipment costs. For example, the cost of the reception equipment for the satellite system chosen would be at least as sophisticated as ITFS reception equipment which is estimated at $2,500 per school. A portion of this cost is for a tower to position the antenna in the line of sight broadcast pattern of the ITFS transmitting antenna. Because of the relatively high elevation angle of the satellite, towers would not be necessary. It is assumed that common design, use of integrated circuitry, and large production volume would reduce reception costs to $1,000 per school which is below present ITFS costs.

The reception costs are related to the effective radiated power of the satellite. An increase in ERP produces a decrease in reception cost per reception point, since less sensitive reception devices can be used. However, this causes an increase in satellite weight and cost. Increases in ERP are limited by the weights of the transmitter and power source that can be placed into orbit by available launch vehicles. The satellite system proposed here will not require any increase in the booster capability of vehicles which are presently available.

The system will be described only for the regional environment. Smaller environments would be impractical for any satellite system, and larger environments would require a somewhat different system.

System Bounds

The approach taken to estimating costs for a satellite system was to define reasonable system bounds and apply them to a computer system model available at the General Electric Company's Missile and Space Division. The computer model synthesizes a satellite system based on the specified bounds. It then determines the cost of such a system.

The system bounds are as follows:

Coverage area: 500,000 square miles
Signal quality: TASO grade 1
Transmission frequency: 2,500 MHz
Signal modulation: AM
Satellite orbit: Synchronous
Man-made noise level: Equivalent to urban area
Cost per reception point: $1,000
Operating time: 23 hours per day
Number of TV channels: 4
Coverage area location: Below 40° N. latitude

Many other sets of system bounds could be introduced to the model to produce a variety of system configurations and costs. The set chosen here is not optimum with respect to cost or efficiency. Given an actual situation, the model would produce a set of optimum configurations for trade-off analysis. The reasons for choosing this set of bounds are described below.

Coverage Area. The 500,000 square mile coverage area is consistent with the regional area used throughout this study. Also, it is probably the smallest practical area to consider.

Signal Quality. Excellent signal quality is prescribed for the model to allow for possible degradation and still provide a high quality picture.

Transmission Frequency. The 2,500 MHz (2.5 GHZ) channels have already been allocated for educational use. The assumption was made that it would be easier to select some of these channels for an educational satellite than to invade the UHF or microwave channels.

Signal Modulation. Amplitude modulation is chosen because of bandwidth considerations rather than cost or technical considerations. FM transmission requires a larger bandwidth than AM. An FM system would probably be less costly; however, it would require removing more than four channels from the ITFS band.

Satellite Orbit. A geostationary orbit is chosen to provide maximum time coverage from a single satellite.

Man-Made Noise Level. A noise level equivalent to that found in urban areas is used even though many reception points are located in areas with less interference.

Cost Per Reception Point. Individual school buildings are the reception points. The cost per reception point covers the costs of the antenna, pre-amplifier, and down-converter. The output of the reception equipment is presented to the school's distribution amplifier. One thousand dollars is chosen as a reasonable figure for a building installation because it is believed that reception equipment could be acquired at this price in the 1970's.

Operating Time. The daily operating time chosen is longer than the school day to provide time for other uses of the system (night classes, teacher training, etc.)

Coverage Area Location. A coverage area location below 40° latitude is somewhat easier to cover than higher latitudes. This area also represents a population density equivalent to the density in the hypothetical region.

The computer model is iterative in nature. It first uses the input bounds and stored data to determine the minimum effective radiated power needed to service a selected ground receiver design. Then, using this minimum ERP and the input bounds, it selects a minimum cost satellite design. Using a satellite life of two years and a ground equipment life of 10 years, it then determines the costs associated with the system for a 10 year operation.

System Parameters and Costs

Using the set of technical bounds described previously, the model produced the following system parameters and costs.

Summary of Satellite Parameters

Total satellite weight	1,795 lbs.
Effective radiated power	71.29 dbw.
Antenna gain	37.5 db
Solar cell area	1,135 sq. ft.
Conservative satellite life	2 years

Summary of Technical System Costs (Distribution)

Development cost	$21,500,000
Cost to put satellite in orbit (hardware & launch)	$18,300,000
Cost for 5 satellites & launch	$91,500,000
Cost of ground station	$20,500,000

The reception equipment for satellite use consists of a 10 foot parabolic dish antenna, preamplifier, and frequency converter. It supplies a four-channel input to the school's distribution amplifier. The cost of the equipment used in the model is $1,000 per school. This cost is based on quantities of 10,000 or more and on the use of hybrid integrated circuitry. To this must be added the school's base cost for television sets, cabling, and a distribution amplifier.

The following are the reception costs for the regional satellite system.

154,000 TV receivers at $150	$23,100,000
Antennas, receivers and distribution	48,010,000
Total equipment cost	$71,110,000
Maintenance at 10%	$ 7,111,000

The production costs associated with the satellite system are equivalent to those of the other regional systems. The above costs are listed on the cost data sheets under the production, reception and distribution categories. The costs are then amortized over the period of their use to find an annual cost which would be constant for the life of the system. To obtain this annual cost, the following assumptions were made.

- Initial administration, planning, and training are amortized over 10 years.
- Television receivers and other reception equipments are amortized over five years.
- Educational materials are amortized over five years.
- Satellites are amortized over two years.
- All other equipment is amortized over 10 years.
- Interest rate assumed is 5%; therefore, the capital recovery factors are .537 for two years, .231 for five years, and .129 for ten years.

The following example illustrates the method used to find the Equivalent Annual Cost. These figures are found in the cost data sheets which appear at the end of this section.

Reception - Equivalent Annual Cost
Regional Satellite System

TV receivers

$23,100,000 x .231 = $5,336,100

Other equipment

$48,010,000 x .129 = $6,193,290

Initial training and planning

$67,200,000
180,000
$67,380,000 x .129 = $8,692,020

Annual operating cost	$29,739,500
Total	$49,960,910

Distribution - Equivalent Annual Cost
Regional Satellite System

Satellite		
	$18,300,000 x .537	$ 9,827,100
Development		
	$21,500,000 x .129	2,773,500
Ground station		
	$20,500,000 x .129	2,644,500
Training & planning		
	$340,000 x .129	43,860
Operating Cost		2,906,000
Total		$18,194,960

Production - Equivalent Annual Cost
Regional Satellite System

Capital cost		
	$480,000 x .129	$ 61,920
	$6,000,000 x .231	1,519,980
Operating cost		938,500
Total		$2,386,420

Video Tape Recorder Network

Introduction. Instructional materials on video tape recordings can be sent by surface transportation to the schools rather than through the airwaves. Surface transportation includes United States mail, commercial delivery service, or a special fleet of delivery trucks. This method is less expensive than electronic means of distribution if only a small number of schools is involved. For example, when a small to medium-sized school system uses audio language tapes, which are produced in its own facility, it is cheaper to make copies and send them to the individual schools than to install a microwave system to distribute them. However, bulky materials such as video tapes which are expensive to produce and are widely distributed, can be sent to the schools at less cost by electronic means. Surface shipment gives the schools the advantage of being able to schedule the materials as the classroom teacher needs them. Of course, it is necessary to provide a complete library of several copies of each tape for each school and a VTR in each classroom to achieve complete flexibility.

Equipment. The system proposed has up to four helical-scan video tape recorders located at a materials center at each school which can feed up to four different programs to individual classrooms (or even individual students). A central duplication facility records from master tapes and the copies are delivered to the schools by surface transportation. The school maintains a library of the appropriate number of unique hours of programming which requires about 250 square feet @ $18.50 per square foot plus 50 square feet for each VTR. Air conditioning is required for the tape storage. Racks for the film cost about $1 per tape.

Costs for VTR Network Per School

	ONE CHANNEL	TWO CHANNEL	FOUR CHANNEL
Capital Costs			
VTR's + monitor	$ 9,000	$ 18,000	$ 36,000
Building costs + racks	7,300	9,100	10,900
Video tape, 1000 hours *670 hours for 1 channel	*50,000	75,000	75,000
	$ 66,300	$102,100	$121,900
Duplication Cost*	$ 42,000	$ 60,000	$ 60,000

*Because the tapes must be duplicated and sent to each school, $1 per minute is added to initial production costs for duplication, and $1 per tape is added for mailing to the school.

	ONE CHANNEL	TWO CHANNEL	FOUR CHANNEL
Operating Costs			
VTR operators	$ 5,000	$ 5,000	$ 5,000
VTR head repair	800	1,500	2,800
Supplies + power + air conditioning	200	250	300
	$ 6,000	$ 6,750	$ 8,100

Application of VTR Network to a Local School System

	ONE CHANNEL	TWO CHANNEL	FOUR CHANNEL
Capital Costs	$1,193,400	$1,837,800	$2,194,200
Additional Initial Costs for Duplication	756,000	1,080,000	1,080,000
	$1,949,400	$2,917,800	$3,274,200
Operating Costs	$ 108,000	$ 121,500	$ 145,800

The equivalent annual distribution costs of this type of network are about $30 per student for four channels, far greater than any of the other systems. The cost does not decrease with larger areas of application since the costs of each school will remain the same. In addition, production costs may be increased because it will be difficult and expensive to obtain the right to duplicate materials from outside the system. Therefore, this medium is not explored in detail for additional environments.

Equipment Costs for Television Reception

The reception cost for each individual school must be computed before the actual reception equipment costs for a school district can be determined. The costs vary with the size of each school. An average cost per school could be obtained which would produce a fairly accurate cost extrapolation over areas larger than a single school district. This study will use two average costs, one for a small school (elementary) and one for a larger school (secondary). This method is used to illustrate that some costs vary with the number of television sets in use, and some costs are somewhat independent of this number.

The enrollment of the smaller school is 500 to 700 students. It contains 20 or more classrooms, and 20 rooms are wired for television reception. However, only 10 are supplied with television sets. This allows for future expansion or the use of portable sets which can be moved from room to room as needed. Ten television sets in this size school are adequate for the common task used throughout this study.

The larger school's enrollment is 1,000 to 1,500 students. It contains 40 or more classrooms. Thirty-five rooms are wired for television reception, and 20 rooms are supplied with television sets.

Television sets, stands, wiring of distribution coaxial cable, and a distribution amplifier are the basic reception equipment in all of the television systems. To the cost of the equipment is added the particular equipment costs which vary from system to system. Thus, the difference in reception equipment costs for each system consists mainly of the differences in antenna, preamplifier, tower, and converter costs for each system.

Standard 525 line 23" monochrome receivers are used throughout all of the systems. All of the systems also use radio frequency distribution within the school building. No consideration is given in this study to special high resolution television systems using video monitors operating with rasters of more than 525 lines such as might be required in a medical school.

Included in the hardware costs are the costs of installation, sighting of antennas, and system checkout. For airborne and ITFS reception, the cost of an average tower has been included. Thus, some schools would actually have higher or lower reception costs. All reception costs are based on four-channel operation. Operation of fewer channels would not significantly reduce reception costs.

All equipment costs with the exception of the satellite system are based on current prices. The satellite system costs are based on estimated costs for 1973.

Base Cost for Elementary School

Wiring & outlets for 20 rooms at $80	$1,600
Install ten 23" sets with mount at $190	1,900
VHF distribution amplifier	500
	$4,000

Base Cost for Secondary School

Wiring & outlets for 35 rooms at $80	$2,800
Install twenty 23" sets with mount at $190	3,800
VHF distribution amplifier	500
	$7,100

Input Devices for VHF Distribution Amplifier (per building)

UHF capability	$ 525
ITFS capability	2,500
Reception of airborne transmission	2,200
Satellite direct broadcast capability	1,000
Closed-circuit capability	*

* Connection costs are listed under distribution.

Equipment Costs Per School

UHF reception cost

Elementary -	Base cost	$4,000
	Input cost	525
		$4,525
Secondary -	Base cost	$7,100
	Input cost	525
		$7,625

ITFS reception cost

Elementary -	Base cost	$4,000
	Input cost	2,500
		$6,500
Secondary -	Base cost	$7,100
	Input cost	2,500
		$9,600

Airborne reception cost

Elementary - Base cost	$4,000
Input cost	2,200
	$6,200
Secondary - Base cost	$7,100
Input cost	2,200
	$9,300

Satellite reception of direct broadcast cost

Elementary - Base cost	$4,000
Input cost	1,000
	$5,000
Secondary - Base cost	$7,100
Input cost	1,000
	$8,100

Closed-circuit reception cost

Elementary	$4,000
Secondary	$7,100

Medium Size School District

Equipment for UHF reception

14 elementary x $4,525	$ 63,350
4 secondary x $7,625	30,500
	$ 93,850

Equipment for ITFS reception

14 x $6,500	$ 91,000
4 x $9,600	38,400
	$129,400

Equipment for airborne reception

14 x $6,200	$ 86,800
4 x $9,300	37,200
	$124,000

Equipment for satellite reception of direct broadcast

14 x $5,000	$ 70,000
4 x $8,100	32,400
	$102,400

Equipment for closed circuit reception

14 x $4,000	$ 56,000
4 x $7,100	28,400
	$ 84,400

Large City

Equipment for UHF reception

136 x $4,525	$615,400
46 x $7,625	350,750
	$966,150

Equipment for ITFS reception

136 x $6,500	$ 884,000
46 x $9,600	441,600
	$1,325,600

Equipment for airborne reception

136 x $6,200	$ 843,200
46 x $9,300	427,800
	$1,271,000

Equipment for satellite direct broadcast

136 x $5,000	$ 680,000
46 x $8,100	372,600
	$1,052,600

Equipment for closed-circuit reception

136 x $4,000	$ 544,000
46 x $7,100	326,600
	$ 870,600

Metropolitan Area

Equipment for UHF reception

546 x $4,525	$2,470,650
183 x $7,625	1,395,375
	$3,866,025

Equipment for ITFS reception

546 x $6,500	$3,549,000
183 x $9,600	1,756,800
	$5,305,800

Equipment for airborne reception

546 x $6,200	$3,385,200
183 x $9,300	1,701,900
	$5,087,100

Equipment for satellite direct broadcast

546 x $5,000	$2,730,000
183 x $8,100	1,482,300
	$4,212,300

Equipment for closed-circuit reception	
546 x $4,000	$2,184,000
183 x $7,100	1,299,300
	$3,483,300
State	
Equipment for UHF reception	
920 x $4,525	$4,163,000
310 x $7,625	2,363,750
	$6,526,750
Equipment for ITFS reception	
920 x $6,500	$5,980,000
310 x $9,600	2,976,000
	$8,956,000
Equipment for airborne reception	
920 x $6,200	$5,704,000
310 x $9,300	2,883,000
	$8,587,000
Equipment for satellite direct broadcast	
920 x $5,000	$4,600,000
310 x $8,100	2,511,000
	$7,111,000
Equipment for closed-circuit reception	
920 x $4,000	$3,680,000
310 x $7,100	2,201,000
	$5,881,000
Region	
Equipment for UHF reception	
9,200 x $4,525	$41,630,000
3,100 x $7,625	23,637,500
	$65,267,500
Equipment for ITFS reception	
9,200 x $6,500	$59,800,000
3,100 x $9,600	29,760,000
	$89,560,000
Equipment for airborne reception	
9,200 x $6,200	$57,040,000
3,100 x $9,300	28,830,000
	$85,870,000

Equipment for satellite direct broadcast	
9,200 x $5,000	$46,000,000
3,100 x $8,100	25,110,000
	$71,110,000

Equipment for closed-circuit reception	
9,200 x $4,000	$36,800,000
3,100 x $7,100	22,010,000
	$58,810,000

Additional Costs to be Allocated to Production, Distribution, and Reception

Some cost categories which apply to production, distribution, and reception costs are discussed in this section. The costs are allocated to these three categories in the cost data sheets which follow. The categories are:

- Initial Planning
- Administration
- Research and Evaluation
- Training
    - Teacher Training
    - Technical Training
- Related Materials

Initial Planning

Careful planning of the instructional media system can vastly improve the performance of the system. A thorough analysis of the educational problems of the area may prevent costly mistakes. Matching media systems to requirements demands an intensive planning effort by experienced school personnel and consultants. Instructional materials and technical specialists should advise school officials during this phase. Teacher and student attitudes should be examined to identify possible difficulties, and, if possible, community support should be enlisted.

Despite the size of this effort, the planning is left too often to someone who has neither the time nor the capability to undertake the work. Selection of manufacturers, installers, and servicemen is time consuming. Moreover, it is doubtful that any one man is competent in all of the areas of production, reception, and distribution.

A possible range of costs is given below.

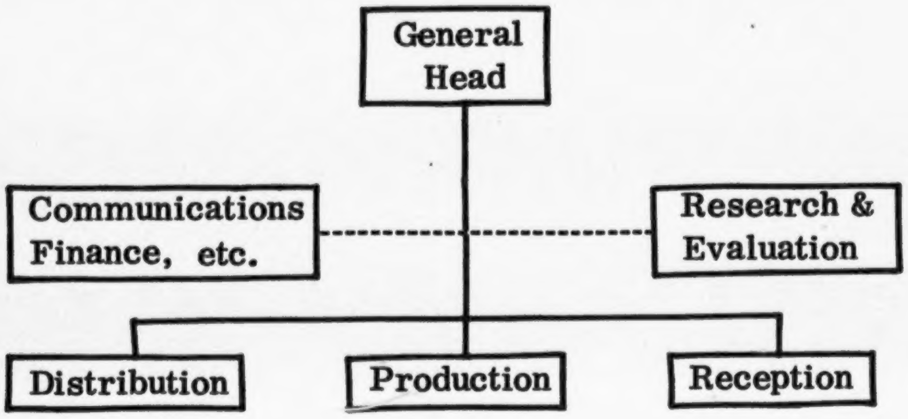
	LOCAL	CITY	METRO	STATE	REGIONAL
General Admin.	$15,000	$15,000	$ 80,000	$120,000	$120,000
Technical & legal	10,000	15,000	20,000	100,000	100,000
Program	10,000	15,000	20,000	80,000	80,000
Technical	5,000	15,000	15,000	100,000	100,000
Communications-travel	2,500	10,000	50,000	100,000	200,000
	$42,500	$70,000	$185,000	$500,000	$600,000

Initial planning costs will be allocated to reception, production, and distribution at the rate of 30%, 30%, and 40% respectively.

Administration

The instructional media systems cannot function properly without top-flight administration. This has been a failure of many of the instructional media projects currently in operation. The management of the distribution system or the production system is usually adequate, but overall management of the complete system is frequently neglected. Communication is a first step in good management, but many managers of media systems have difficulty communicating with the teacher.

The administrative staff varies according to the size of the level of application - local to regional. However, all levels should have roughly the same structure. The general organizational chart consists of an administrative head with line directors for production, reception, distribution, and staff functions such as research and evaluation. For the smaller systems, some of these functions would be part-time or combined under one talented individual. For the larger systems, assistant directors and additional staff functions such as finance are required.



Cost of administrative salaries will vary according to the size of the school system. Estimates of this cost are as follows: $40,000 for the local system, $100,000 for the city, $200,000 for the metropolitan area, $250,000 for the state, and up to $340,000 for the regional system.

In addition to salaries, the largest administrative expense is for communication. This includes expenses for letters, brochures, questionnaires, telephone, travel, and meetings. Since it is imperative that principals, curriculum supervisors, teachers, and all personnel involved with the instructional media system know what is being done, this expense can be considerable. The range might be as follows:

	LOCAL	CITY	METRO	STATE	REGIONAL
Printed Material	$ 3,000	$10,000	$ 25,000	$ 25,000	$ 50,000
Telephone	500	1,000	2,000	4,000	10,000
Travel	1,500	2,000	4,000	10,000	40,000
Meetings	5,000	37,000	79,000	121,000	200,000
	$10,000	$50,000	$110,000	$160,000	$300,000

The cost of administration is distributed as follows: 30% to production, 40% to distribution, and 30% to reception.

Research and Evaluation

The improvement of the educational process must remain the primary goal of administrators. The advantage of using instructional media systems must be in terms of better education and learning since no cost savings are likely to result from their use, at least until the educational structure becomes more flexible. Therefore, the evaluation of results, the formation of better strategies of media use, and better assessment of student needs must be the primary effort of the entire instructional media field. The most effective use of media in education will require:

- A theoretical and empirical understanding of the teacher in the educational process as a coordinator and communicator;
- An understanding of the needs of students for motivation, involvement, care, information, training, culture, socialization . . . ;
- An understanding of the place of formal instruction in the entire educational process, and the utilization of persons, influences, and sources from outside the school as much as possible;
- A working knowledge of the effectiveness of various media in meeting the above needs; and
- A program to help the teacher utilize educational media effectively.

To accomplish these very difficult aims, outstanding persons in the educational media fields must be consulted. For example, production will draw on experts in particular fields of learning for the content; national curriculum leaders will advise on organization; learning theorists will discuss methods; and survey researchers will provide expertise on testing.

Most of the cost of these efforts is included in the production cost. For example, the half-time services of a research and evaluation specialist is provided for in each series of programs (one subject at one level). Artistic and advisory services are also provided in the cost per hour of programming.

The materials for a testing program are provided for in a $.10 per student cost which is included in the reception category. The overall direction of the research and evaluation effort is provided by a full-time two man staff with clerical support at a cost of $50, 000 per year.

While the research and evaluation effort outlined above may seem small when compared to the total task to be accomplished, the present state of knowledge in this area must be considered. The research here is an applied, rather than a basic, effort which can be undertaken only on a national scale because both the funds and the number of qualified people available are limited. Indeed, for the local school system, even the effort shown would be too large. A national program of basic research must be undertaken, the findings of which can be applied at the local level.

Teacher Training

One of the major problems of successfully implementing instructional media in the schools is the lack of teacher preparation for the role of media in the classroom. Some schools have made an effort to prepare the teachers and administrators but, in reality, it is beyond the ability of any school system to reeducate more than the small fraction of its teachers who, through past experience (or lack thereof) accept this innovation most readily. Teachers have formal and informal schooling, years of experience, and in-service training, but virtually none of this training or experience has involved the instructional media as either a tool or a subject. Therefore, it is not surprising that teachers are unprepared to make effective use of media in the classroom. They will often ignore the media unless they have guidance in its use. Teachers must have confidence in the ability of the media to reliably and conveniently deliver materials.

What does this confidence and the teacher's ability to utilize the media entail? First, a basic understanding of the concept of the teacher as an organizer of a meaningful educational experience for each child. This is not a new concept or one which can be applied to only the new media, but it is fundamental if the teacher is going to broaden the range of tools which can provide the educational experience. Secondly, theory and practice in the art of selecting media and other educational experiences to best suit the students' needs. This is a very difficult task to do well, and yet one which largely characterizes a good teacher. Thirdly, knowledge of the content of the instructional materials that may be presented. The teachers must know at least a year in advance what materials will be made available by the media. Otherwise, they cannot possibly plan the educational experience effectively. Finally, instruction and practice in preparing the students for the instructional media materials and in planning and directing activities after the media presentation. The media presentations are usually geared to group rather than individual response. Teachers need written materials, texts, exhibits, experimental kits, reading lists, and suggestions from which to choose in order to receive the maximum benefit from the instructional materials.

These four necessities for effective implementation of the media classroom present an enormous, if not impossible, task. It must be viewed as one which will take a period of years to accomplish. Resources must be applied on a comprehensive, national basis to promote a feedback loop, and this process takes considerable time to build up to a critical level.

In particular, much of the effort in the first item, i.e., the teacher as organizer of the meaningful educational experience, must be done throughout the teacher's education. No one school system or media system can attempt this alone. The colleges and other institutions of teacher education must provide much of the effort. No costs for this effort are estimated in this study.

Similarly, only a small portion of the experience needed in the second item, i.e., ability to select appropriate media, can be provided by the local school. It should, however, provide some training in the particular media used. A cost is included for this item.

The third item, the necessity of advance information concerning what materials will be made available by the instructional media, is one which the local school system or the instructional media system must provide. All too often this is overlooked. Obviously, if the materials are created as the course progresses, it is impossible to give substantial advance information. For this reason, the cost of programming in this study is included as a lump sum cost before service starts. It is unfortunate that only repeated actual use of the materials will fully inform the teachers of what is available, but much can and should be done in advance. Costs are included for a reasonable effort in this direction.

Again, with the fourth item, i.e., experience in utilization of the media materials, only part of the necessary experience can be provided by the school system before a new media is introduced. Some costs are included for this effort in combination with the second item, the ability to select appropriate media.

As noted above, the activities are an essential part of the overall effort to provide teachers with the ability and confidence to use media. In particular, they represent what the local school system can and must do to provide experience in planning, using the instructional material, and in transmitting information about the programming. The following activities are included.

- An initial summer institute provides training for 10% of the teachers in a system @ $2,000 per teacher plus $20,000 for each institute.
- Advance notification of the availability of materials is estimated at $.50 per teacher.
- Fifty dollars per teacher is estimated for previewing materials.

Technical Training

Initial training of two weeks to two months is usually adequate for operating personnel other than teachers. The only cost is for salaries. The cost of an initial training period appropriate for each system at its inception is specified. Once the system is operating, new technicians must also undergo a training period. Approximately one-third of the initial training cost is shown as a yearly cost since annual turnover is estimated at that level.

No technical training costs in the reception category are incurred because it is assumed that this will usually be done by the local independent television installer.

Related Materials

Instructional materials will be distributed to students and teachers to supplement the media. These may be presented in a variety of forms, e.g., programmed sheets, films, tapes, etc. Their purpose will be to present supplementary readings, experiments, outlines, summaries, motivational reinforcement, and directions for individualized follow-up. There should be teachers' guides to explain the related instructional materials, methods of preparing for them, and ways to follow up the presentation. In some cases, a text may be used. If instructional media materials are developed for national use, some of these materials may become available in coordinated packages. They should be developed together with the production of the major media materials. Costs for the creation of related materials are included in the "high quality" production costs. The cost of a minimal effort for providing copies of these materials at the classroom level follows.

Teachers manuals $2 each x 1/3 years use x 8 subjects = $5

Student materials $.04 x 8 subjects x 30 students = $10

$15/classroom

A minimal cost is included in the production category for supervising the distribution of related materials.

Instructional Television for the Eastern Megalopolis

A particularly important region of the United States is the so-called urban corridor from Boston to Washington. A substantial portion of the nation's population, almost 30 million persons, lives in the region. This area is sufficiently different in population density to be considered separately in this report.

Almost all of the region is now served by the educational stations in Washington, Philadelphia, New York, Hartford, Norwich, and Boston which are members of the Eastern Educational Network. The network presently leases interconnection facilities for the Boston to Washington route from the Bell system. The present service is a one-channel service, except in Philadelphia where it is a two-channel service. Although many instructional programs are broadcast, the present EEN cannot provide the cultural or the educational programming assumed for this study.

Providing an instructional television system for the megalopolis would be difficult. Although a wide range of systems is available, few meet the technical specifications needed for such an application. Both airborne and satellite coverage would be possible, but wasteful. The population density is probably too great for each school district to use standard ITFS because of electronic interference between systems. If the proposed higher-powered ITFS were used, the frequency band would not be available to the non-educational users of this shared band of fixed service. This is the only area in the country for which there are problems in obtaining UHF construction permits. It would be impossible to get four channels without changing the frequencies of some stations.

In order to provide an instructional television system to the eastern megalopolis, lease lines must be obtained from the telephone company. Applying the previous techniques for estimating interconnection mileage, line charges would be 15 million dollars, or about $2 per student per year. If production were kept at the regional level assumed in the model, it would cost about $.40 per student per year, and reception costs would be $3 per student per year. Total cost would then be in the $5-6 range for four channels which is a reasonable figure.

Community Antenna Television

Community Antenna Television is also known as cable television. The television signal is brought into the house by cable instead of through the airwaves. In recent years, community antenna television (CATV) has grown from a very minor service for small towns in a few fringe television areas to a multihundred million dollar business serving 3,000,000 subscribers. However, its potential growth has been reduced by the recent FCC decision banning CATV from moving into the cities composing the top 100 television markets.

In many instances, CATV companies have offered to carry educational or instructional television channels and provide the service free or at reduced rates to the schools. There are several reasons for this offer of free service.

- They are interested in contributing to education.
- Most CATV systems have a 12-channel capability but only three or four different sets of programs to distribute. Adding ETV or ITV channels means they can provide more channels of service which may attract potential customers.
- It is difficult to get franchises from cities to install CATV systems, and free service for schools builds goodwill.

The CATV system consists of microwave and cable with amplifiers at intervals. This is basically the same system used by the telephone company for the closed-circuit system discussed above. In fact the same cable type might be used for the main line of the CATV system. Therefore, it is not worthwhile to cost the CATV system as a separate instructional media system.

If the CATV companies will carry the signal free to all of the schools in a district, the school systems should take advantage of their offer. However, the CATV systems may not cover the fringes of the school district since they do not usually cover rural areas. It is even more likely that the CATV systems will not connect with other local school systems which might wish to share programming. If more commercial channels become available, there is some doubt as to how long services would be continued at no charge.

Cost Data Sheets

The following pages are cost data sheets which were used to collect the costs of the production, distribution, and reception for each instructional media system and in each area of application. These costs were obtained from the preceding descriptions. However, in order to keep the number of cost categories to a reasonable number, costs for several items are sometimes combined which are not traceable directly to costs in the descriptions. For example, the costs for programming at the local level for every television system include one item entitled Programs and Materials - $80,500. This figure includes the following:

Rental of Programs (50% of 1,000 hours)	$72,500
Related Materials (printed)	5,000
Current Programming Talent Costs (sepcials)	3,000
	$80,500

In addition, the production costs include another item of $150,000 under Personnel and Supplies. This figure covers the costs of the other 50% of 1,000 hours which is produced locally at $300 per hour. Finally the $30,000 Equipment and Facilities capital item represents an additional studio for programming administrative matters and special events. It is assumed that the operating costs would be covered by the $150,000 except for the $3,000 above. Similar adjustments have been made in the costs discussed in the detailed descriptions of the media to reflect a workable unit at each application level for each media system.

The equivalent annual cost listed on the cost data sheets is a combination of the annual operating cost and amortization of the capital cost. A sample calculation is shown in the satellite section. The amortization includes depreciation over the appropriate life span plus interest on the undepreciated balance. The initial programming and the television sets are amortized over five years. All other items are amortized over 10 years except for buildings which are amortized over 25 years. An interest rate of 5% is used.

Per pupil costs are shown in Tables 44 through 49. A graphic presentation of these data is included in the section entitled "Cost Estimates".

TABLE 25

FOUR-CHANNEL AIRBORNE T.V. — STATE

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	150,000	127,000
Programs and Materials	5,625,000	274,375
Research and Evaluation		50,000
Total:	$6,075,000	$755,875

Equivalent Annual Cost $2,113,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$1,333,000
Equipment and Facilities	$11,657,500	
Planning	200,000	
Administration and Training	60,000	184,000
Total:	$11,917,500	$1,517,000

Equivalent Annual Cost $3,054,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 6,720,000	$1,681,600
Equipment	8,587,000	858,700
Administration and Planning	150,000	123,000
Related Materials		462,000
Research and Evaluation		100,000
Total:	$15,457,000	$3,225,300

Equivalent Annual Cost $6,095,000

TABLE 26

FOUR-CHANNEL AIRBORNE T.V. — REGION

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	180,000	196,000
Programs and Materials	6,000,000	388,000
Research and Evaluation		50,000
Total:	$6,480,000	$938,500

Equivalent Annual Cost $2,386,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$10,664,000
Equipment and Facilities	$79,916,000	
Planning	240,000	
Administration and Training	480,000	416,000
Total:	$80,636,000	$11,080,000

Equivalent Annual Cost $21,482,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 67,200,000	$16,816,500
Equipment	85,870,000	8,587,000
Administration and Planning	180,000	192,000
Related Materials		4,620,000
Research and Evaluation		1,000,000
Total:	$153,250,000	$31,215,500

Equivalent Annual Cost $59,743,000

TABLE 27

FOUR-CHANNEL UHF BROADCAST T.V. — LOCAL

PRODUCTION	CAPITAL		OPERATING
Personnel and Supplies			$150,000
Equipment and Facilities	$30,000		
Administration, Training, and Planning	12,750		17,000
Programs and Materials			85,500
Research and Evaluation			20,000
Total	$42,750		$267,500
Equivalent Annual Cost		$273,000	

DISTRIBUTION	CAPITAL		OPERATING
Personnel and Supplies			$119,000
Equipment and Facilities	$878,000		
Planning	17,000		
Administration and Training	2,000		20,700
Total:	$897,000		$139,700
Equivalent Annual Cost		$255,400	

RECEPTION	CAPITAL		OPERATING
Teacher Training	$120,000		$25,250
Equipment	93,850		9,400
Administration and Planning	12,750		15,000
Related Materials			6,600
Research and Evaluation			1,500
Total:	$226,600		$57,750
Equivalent Annual Cost		$ 96,550	

TABLE 28

FOUR-CHANNEL UHF BROADCAST T. V. — CITY

PRODUCTION	CAPITAL		OPERATING
Personnel and Supplies			$360,000
Equipment and Facilities	$30,000		
Administration, Training, and Planning	21,000		48,000
Programs and Materials			63,500
Research and Evaluation			50,000
Total:	$51,000		$521,500
Equivalent Annual Cost		$528,100	

DISTRIBUTION	CAPITAL		OPERATING
Personnel and Supplies			$119,000
Equipment and Facilities	$821,300		
Planning	28,000		
Administration and Training	2,000		60,700
Total	$851,300		$179,700
Equivalent Annual Cost		$289,500	

RECEPTION	CAPITAL		OPERATING
Teacher Training	$1,020,000		$252,000
Equipment	966,150		96,600
Administration and Planning	21,000		45,000
Related Materials			68,400
Research and Evaluation			15,000
Total:	$2,007,150		$477,000
Equivalent Annual Cost		$834,500	

TABLE 29

FOUR-CHANNEL UHF BROADCAST T.V. — METRO

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	55,500	97,000
Programs and Materials	4,875,000	177,125
Research and Evaluation		50,000
Total:	$5,230,500	$ 628,625

Equivalent Annual Cost $1,801,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 119,000
Equipment and Facilities	$1,348,600	
Planning	74,000	
Administration and Training	2,000	124,700
Total:	$1,424,600	$ 243,700

Equivalent Annual Cost $427,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$4,020,000	$1,010,000
Equipment	3,866,000	386,600
Administration and Planning	55,500	93,000
Related Materials		273,600
Research and Evaluation		60,000
Total:	$7,941,500	$1,823,200

Equivalent Annual Cost $3,242,000

TABLE 30

FOUR-CHANNEL UHF BROADCAST T. V. — STATE

PRODUCTION (high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	150,000	127,000
Programs and Materials	5,625,000	274,375
Research and Evaluation		50,000
Total:	$6,075,000	$ 755,875

Equivalent Annual Cost $2,113,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$1,959,000
Equipment and Facilities	$15,633,000	
Planning	200,000	
Administration and Training	50,000	180,000
Total:	$15,883,000	$2,139,000

Equivalent Annual Cost $4,188,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$6,720,000	$1,681,600
Equipment	6,526,750	652,600
Administration and Planning	150,000	123,000
Related Materials		462,000
Research and Evaluation		100,000
Total:	$13,396,750	$3,019,200

Equivalent Annual Cost $5,413,000

TABLE 31

FOUR-CHANNEL UHF BROADCAST T.V. – REGION

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	180,000	196,000
Programs and Materials	6,000,000	388,000
Research and Evaluation		50,000
Total:	$6,480,000	$ 938,500

Equivalent Annual Cost $2,386,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$14,773,000
Equipment and Facilities	$201,895,000	
Planning	240,000	
Administration and Training	600,000	456,000
Total:	$202,735,000	$15,229,000

Equivalent Annual Cost $41,382,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$67,200,000	$16,816,500
Equipment	65,267,500	6,526,700
Administration and Planning	180,000	192,000
Related Materials		4,620,000
Research and Evaluation		1,000,000
Total:	$132,647,500	$29,155,200

Equivalent Annual Cost $52,924,000

TABLE 32

FOUR-CHANNEL ITFS T. V. — LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 150,000
Equipment and Facilities	$ 30,000	
Administration, Training and Planning	12,750	17,000
Programs and Materials		80,500
Research and Evaluation		20,000
Total:	$ 42,750	$ 267,500
Equivalent Annual Cost	$273,000	

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 40,000
Equipment and Facilities	$ 198,000	
Planning	17,000	
Administration and Training	500	20,200
Total:	$ 215,500	$ 60,200
Equivalent Annual Cost	$88,000	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 120,000	$ 25,250
Equipment	129,400	12,900
Administration and Planning	12,750	15,000
Related Materials		6,600
Research and Evaluation		1,500
Total:	$ 262,150	$ 61,250
Equivalent Annual Cost	$108,250	

TABLE 33

FOUR-CHANNEL ITFS T.V. — CITY

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 360,000
Equipment and Facilities	$ 30,000	
Administration, Training and Planning	21,000	48,000
Programs and Materials		63,500
Research and Evaluation		50,000
Total:	$ 51,000	$ 521,500
Equivalent Annual Cost	$528,100	

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 40,000
Equipment and Facilities	$ 198,000	
Planning	28,000	
Administration and Training	500	60,200
Total:	$ 226,500	$ 100,200
Equivalent Annual Cost	$129,400	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$1,020,000	$ 252,500
Equipment	1,325,600	132,600
Administration and Planning	21,000	45,000
Related Materials		68,400
Research and Evaluation		15,000
Total:	$2,366,600	$ 513,500
Equivalent Annual Cost	$954,000	

TABLE 34

FOUR-CHANNEL ITFS T. V. — METRO

PRODUCTION (high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	55,500	97,000
Programs and Materials	4,875,000	177,125
Research and Evaluation		50,000
Total:	$5,230,500	$ 628,625

Equivalent Annual Cost $1,801,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 84,000
Equipment and Facilities	$ 590,000	
Planning	74,000	
Administration and Training	2,500	124,800
Total:	$ 666,500	$ 208,800

Equivalent Annual Cost $295,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$4,020,000	$1,010,000
Equipment	5,305,800	530,500
Administration and Planning	55,500	93,000
Related Materials		273,600
Research and Evaluation		60,000
Total:	$9,381,300	$1,967,100

Equivalent Annual Cost $3,718,000

TABLE 35

FOUR-CHANNEL MEDIUM POWERED ITFS T.V. – STATE

PRODUCTION (high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	150,000	127,000
Programs and Materials	5,625,000	274,375
Research and Evaluation		50,000
Total:	$6,075,000	$ 255,875

Equivalent Annual Cost $2,113,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 263,500
Equipment and Facilities	5,057,800	
Planning	200,000	
Administration and Training	12,000	168,000
Total:	$5,269,800	$ 431,500

Equivalent Annual Cost $1,111,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$6,720,000	$1,681,600
Equipment	8,956,000	895,600
Administration and Planning	150.000	123,000
Related Materials		462,000
Research and Evaluation		100,000
Total:	$15,826,000	$3,262,200

Equivalent Annual Cost $6,217,000

TABLE 36

FOUR-CHANNEL MEDIUM POWERED ITFS T.V. – REGION

PRODUCTION (high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training, and Planning	180,000	196,000
Programs and Materials	6,000,000	388,000
Research and Evaluation		50,000
Total:	$6,480,000	$ 938,500

Equivalent Annual Cost $2,386,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$2,916,000
Equipment and Facilities	$65,263,900	
Planning	240,000	
Administration and Training	144,000	
Total:	$65,647,900	$3,220,000

Equivalent Annual Cost $11,689,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$67,200,000	$16,816,500
Equipment	89,560,000	8,956,000
Administration and Planning	180,000	192,000
Related Materials		4,620,000
Research and Evaluation		1,000,000
Total:	$156,940,000	$31,584,500

Equivalent Annual Cost $60,965,000

TABLE 37

FOUR-CHANNEL CLOSED-CITCUIT T. V. — LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 150,000
Equipment and Facilities	$ 30,000	
Administration, Training and Planning	12,750	17,000
Programs and Materials		80,500
Research and Evaluation		20,000
Total:	$ 42,750	$ 267,500
Equivalent Annual Cost	$273,000	

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 56,000
Equipment and Facilities	$ 178,000	
Line Rental Charge		37,750
Planning	17,000	
Administration and Training	3,000	21,000
Total:	$ 198,000	$ 114,750
Equivalent Annual Cost	$140,300	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 120,000	$ 25,250
Equipment	84,400	8,400
Administration and Planning	12,750	15,000
Related Materials		6,600
Research and Evaluation		1,500
Total:	$ 217,150	$ 56,750
Equivalent Annual Cost	$93,350	

TABLE 38

FOUR-CHANNEL CLOSED-CIRCUIT T.V. — CITY

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 360,000
Equipment and Facilities	$ 30,000	
Administration, Training and Planning	21,000	48,000
Programs and Materials		63,500
Research and Evaluation		50,000
Total:	$ 51,000	$ 521,500
Equivalent Annual Cost	$528,100	

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 56,000
Equipment and Facilities	$ 178,000	
Line Rental		147,100
Planning	17,000	
Administration and Training	3,000	61,000
Total:	$ 198,000	$ 264,100
Equivalent Annual Cost	$289,600	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$1,020,000	$ 252,500
Equipment	870,600	87,000
Administration and Planning	21,000	45,000
Related Materials		68,400
Research and Evaluation		15,000
Total:	$1,911,600	$ 467,900
Equivalent Annual Cost	$803,300	

TABLE 39

FOUR-CHANNEL CLOSED-CIRCUIT — METRO

PRODUCTION (high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training and Planning	55,000	97,000
Programs and Materials	4,875,000	177,125
Research and Evaluation		50,000
Total:	$5,230,500	$ 628,625

Equivalent Annual Cost $1,801,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 56,000
Equipment and Facilities	$ 178,000	
Line Rental		1,095,500
Planning	74,000	
Administration and Training	3,000	125,000
Total:	$ 255,000	$1,276,500

Equivalent Annual Cost $1,309,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$4,020,000	$1,010,000
Equipment	3,483,000	348,300
Administration and Planning	55,500	93,000
Related Materials		273,600
Research and Evaluation		60,000
Total:	$7,558,500	$1,784,900

Equivalent Annual Cost $3,115,000

TABLE 40

FOUR-CHANNEL CLOSED-CIRCUIT T.V. - STATE

PRODUCTION 9high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training and Planning	150,000	127,000
Programs and Materials	5,625,000	274,375
Research and Evaluation		50,000
Total:	$6,075,000	$ 755,875

Equivalent Annual Cost $2,113,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 56,000
Equipment and Facilities	$ 178,000	
Line Rental		5,375,700
Planning	200,000	
Administration and Training	3,000	165,000
Total:	$ 381,000	$5,596,700

Equivalent Annual Cost $5,646,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$6,720,000	$1,681,600
Equipment	5,881,000	588,100
Administration and Planning	150,000	123,000
Related Materials		462,000
Research and Evaluation		100,000
Total:	$12,751,000	$2,954,700

Equivalent Annual Cost $5,199,000

TABLE 41

FOUR-CHANNEL CLOSED-CIRCUIT T.V. — REGION

PRODUCTION (high quality)	CAPITAL	OPERATING
Personnel and Supplies		$ 304,500
Equipment and Facilities	$ 300,000	
Administration, Training and Planning	180,000	196,000
Programs and Materials	6,000,000	388,000
Research and Evaluation		50,000
Total:	$6,480,000	$ 938,500

Equivalent Annual Cost $2,386,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 56,000
Equipment and Facilities	$ 178,000	
Line Rental		68,458,000
Planning	240,000	
Administration and Training	3,000	257,000
Total:	$ 421,000	$68,771,000

Equivalent Annual Cost $68,825,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$67,200,000	$16,816,500
Equipment	58,810,000	5,881,000
Administration and Planning	180,000	192,000
Related Materials		4,620,000
Research and Evaluation		1,000,000
Total:	$126,190,000	$28,509,500

Equivalent Annual Cost $50,787,000

TABLE 42

FOUR-CHANNEL SATELLITE T.V. — REGION

PRODUCTION	CAPITAL	OPERATING
Equipment and Facility	$ 300,000	
Operation and Maintenance		$ 308,500
Administration and Planning	180,000	192,000
Programming	6,000,000	388,000
Research and Evaluation		50,000
Total:	$6,480,000	$ 938,500
Equivalent Annual Cost	$2,386,000	

DISTRIBUTION	CAPITAL	OPERATING
Engineering Development	$21,500,000	
Satellite System	91,500,000	
Ground System	20,500,000	$2,600,000
Training	100,000	50,000
Administration and Planning	240,000	256,000
Total:	$133,840,000	$2,906,000
Equivalent Annual Cost	$18,195,000	

RECEPTION	CAPITAL	OPERATING
Equipment	$71,110,000	$ 7,111,000
Training and Materials	67,200,000	21,436,500
Administration and Planning	180,000	192,000
Research Evaluation and Testing		1,000,000
Total:	$138,490,000	$29,739,500
Equivalent Annual Cost	$49,961,000	

TABLE 43

FOUR-CHANNEL VTR NETWORK — LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		$ 150,000
Equipment and Facilities	$ 30,000	
Administration, Training and Planning	12,750	17,000
Programs and Materials		80,500
Research and Evaluation		20,000
Total:	$ 42,750	$ 267,500

Equivalent Annual Cost $273,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$ 145,800
Equipment and Facilities	$3,274,200	
Planning	17,000	
Administration and Training	7,500	22,500
Total:	$3,298,700	$ 168,300

Equivalent Annual Cost $593,850

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 120,000	$ 25,250
Equipment	84,400	8,400
Administration and Planning	12,750	15,000
Related Materials		6,600
Research and Evaluation		1,500
Total:	$ 217,150	$ 56,750

Equivalent Annual Cost $93,350

TABLE 44

COSTS PER PUPIL -- AIRBORNE SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL							
Equivalent Annual Cost							
CITY							
Equivalent Annual Cost							
METRO							
Equivalent Annual Cost							
STATE	$ 6.08	$ 0.76	$11.92	$ 1.52	$15.46	$ 3.23	
Equivalent Annual Cost	$ 2.11		$ 3.05		$ 6.10		$11.26
REGION	$ 0.65	$ 0.09	$ 8.06	$ 1.11	$15.32	$ 3.12	
Equivalent Annual Cost	$ 0.24		$ 2.15		$ 5.97		$ 8.36

TABLE 45

COSTS PER PUPIL -- UHF BROADCAST SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$ 2.85	$17.83	$59.80	$ 9.31	$15.11	$ 3.85	
Equivalent Annual Cost	$18.20		$17.03		$ 6.44		$41.67
CITY	$ 0.34	$ 3.48	$ 5.68	$ 1.20	$13.38	$ 3.18	
Equivalent Annual Cost	$ 3.52		$ 1.93		$ 5.56		$11.01
METRO	$ 8.72	$ 1.05	$ 2.37	$ 0.41	$13.24	$ 3.04	
Equivalent Annual Cost	$ 3.00		$ 0.71		$ 5.40		$ 9.11
STATE	$ 6.08	$ 0.76	$15.88	$ 2.14	$13.40	$ 3.02	
Equivalent Annual Cost	$ 2.11		$ 4.19		$ 5.41		$11.71
REGION	$ 0.65	$ 0.09	$20.27	$ 1.52	$13.26	$ 2.92	
Equivalent Annual Cost	$ 0.24		$ 4.14		$ 5.29		$ 9.67

TABLE 46

COSTS PER PUPIL -- ITFS SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$ 2.85	$17.83	$14.37	$ 4.01	$17.48	$ 4.08	
Equivalent Annual Cost	$18.20		$ 5.87		$ 7.22		$31.29
CITY	$ 0.34	$ 3.48	$ 1.51	$ 0.67	$ 15.78	$ 3.42	
Equivalent Annual Cost	$ 3.52		$ 0.86		$ 6.36		$10.74
METRO	$ 8.72	$ 1.05	$ 1.11	$ 0.35	$15.64	$ 3.28	
Equivalent Annual Cost	$ 3.00		$ 0.49		$ 6.20		$ 9.69
STATE	$ 6.08	$ 0.76	$ 5.27	$ 0.43	$15.83	$ 3.26	
Equivalent Annual Cost	$ 2.11		$ 1.11		$ 6.22		$ 9.44
REGION	$ 0.65	$ 0.09	$ 6.56	$ 0.32	$15.69	$ 3.16	
Equivalent Annual Cost	$ 0.24		$ 1.17		$ 6.10		$ 7.51

TABLE 47

COSTS PER PUPIL -- CLOSED CIRCUIT SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$ 2.85	$17.83	$13.20	$ 7.65	$14.48	$ 3.78	
Equivalent Annual Cost	$18.20		$ 9.35		$ 6.22		$33.77
CITY	$ 0.34	$ 3.48	$ 1.32	$ 1.76	$12.74	$ 3.12	
Equivalent Annual Cost	$ 3.52		$ 1.93		$ 5.36		$10.81
METRO	$ 8.72	$ 1.05	$ 0.42	$ 2.13	$12.60	$ 2.97	
Equivalent Annual Cost	$ 3.00		$ 2.18		$ 5.19		$10.37
STATE	$ 6.08	$ 0.76	$ 0.38	$ 5.60	$12.75	$ 2.95	
Equivalent Annual Cost	$ 2.11		$ 5.65		$ 5.20		$12.96
REGION	$ 0.65	$ 0.09	$ 0.04	$ 6.88	$12.62	$ 2.85	
Equivalent Annual Cost	$ 0.24		$ 6.88		$ 5.08		$12.20

TABLE 48

COSTS PER PUPIL -- SATELLITE SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL							
Equivalent Annual Cost							
CITY							
Equivalent Annual Cost							
METRO							
Equivalent Annual Cost							
STATE							
Equivalent Annual Cost							
REGION	$ 0.65	$ 0.09	$13.38	$ 0.29	$13.85	$ 2.97	
Equivalent Annual Cost	$ 0.24		$ 1.82		$ 5.00		$ 7.06

TABLE 49

COSTS PER PUPIL -- VTR NETWORK SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$ 2.85	$17.83	$219.91	$11.22	$14.48	$ 3.78	
Equivalent Annual Cost	$18.20		$39.59		$ 6.22		$64.01
CITY							
Equivalent Annual Cost							
METRO							
Equivalent Annual Cost							
STATE							
Equivalent Annual Cost							
REGION							
Equivalent Annual Cost							

SECTION C

AUDIOVISUAL MEDIA SYSTEM

AUDIOVISUAL MEDIA SYSTEM

Audiovisual media systems are widely used by many school systems throughout the country. Hardware and software materials associated with a variety of still and motion picture systems are being circulated to schools from many media centers and AV libraries. The majority of programs for these systems have been acquired, rented, or obtained free from sources outside of education such as government, industry, and film production companies. These materials are delivered to the school systems for classroom use in a variety of ways. Some of the methods used for distribution are school truck, U. S. mail, and independent delivery service.

AV media systems may be divided into two major categories - 16mm sound film and projectors, and slides, filmstrips, overhead transparencies, with their related projectors and playback equipment.

A system of 16mm sound films and projectors has the following characteristics:

Production - generally acquired from external sources
Distribution - necessitates a special facility (media center, audiovisual center) for scheduling, storage, and delivery of films
Reception - 16mm projectors and screens

A system of slides, filmstrips, transparencies, and related equipment has the following characteristics:

Production - program materials acquired from external sources or produced internally
Distribution - easily accomplished in each school building or existing book library if a special facility does not exist
Reception - each form requires its own projectors and screens

Costs associated with the 16mm films and projectors are substantial compared to costs associated with slides, filmstrips, and audio tapes. The characteristics of the latter system are such that the necessary materials, equipment, and facilities could easily be accommodated by the system required for 16mm films and projectors at little additional cost. Therefore, in the interest of simplicity, the remainder of this discussion will focus on the costs related to planning, implementing, and operating a 16mm system with brief reference to the second category where appropriate.

Production

Films may be acquired by either renting or buying existing film or by producing films designed to meet specific instructional requirements.

Films which are available for purchase and/or rent are produced by government agencies, universities and colleges, federally funded curriculum study groups, and individual film production companies. Figure 25 was developed to depict the relationship of these production sources available to the educational community.

In most cases, films which are available for rent or purchase are not produced with a specific curriculum or text in mind nor are they necessarily correlated with the teacher's needs. There is little or no feedback from the user to the producer.

Films traditionally have not been produced for instructional purposes but rather to augment or supplement the subject matter that is being taught. A few film series in recent years, funded by the National Science Foundation, have been produced in conjunction with a specific course of study and are correlated with some widely used textbooks. Film divisions of three major textbook companies have historically dominated the educational film industry. Newer, smaller companies, have entered the production area in the past 10 years and tend to produce more creative programs which meet user needs in a shorter period of time. Theoretically, an audiovisual center tries to match the instructional needs of a school system with commercially produced programs. On many occasions, a commercial production company will solicit the advice and counsel of many audiovisual directors prior to producing a program. Unfortunately, most film producers do not utilize a large enough staff of educators, curriculum and media specialists, and teachers to assist them prior to the production of a program. Also, producers currently do not survey a sufficiently large number of school systems to determine their programming needs.

However, there are over 10,000 film titles currently in existence which are available for instructional purposes. Table 50 presents an analysis by subject area of the majority of these titles.

Current Pricing

The pricing practices of commercial film producers have evolved from a "what the consumer will bear" philosophy, rather than from a formula predicated on costs. Consequently, the trend has been to increase the price of a film a small amount each year.

Tables 51 and 52 illustrate some of the price variations of films.

An average price of $200 per film print was selected as a representative value for estimating the cost of a 16mm film system.

There are several alternatives to purchasing or renting films. For example, the school system can subcontract the production of films to a production company. The second alternative is to have the media system include a production facility. Production costs vary depending upon a wide range of variables such as a source of production, number of people and time involved, and number of creative optical effects. Assuming that materials are subcontracted to a production company, a representative range of production costs for a 20 minute color program is $20,000 to $50,000.

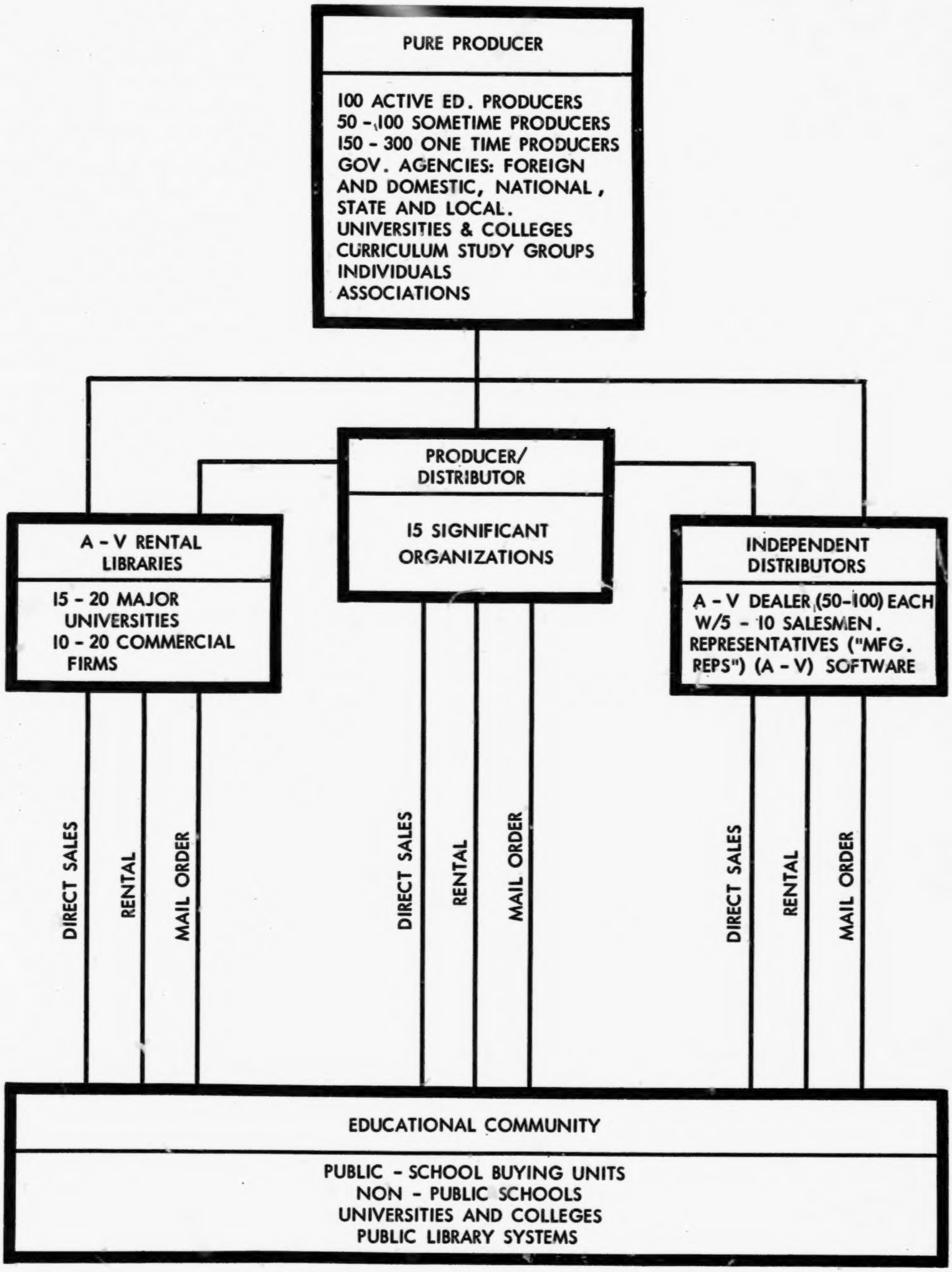

PURE PRODUCER
100 ACTIVE ED. PRODUCERS
50 - 100 SOMETIME PRODUCERS
150 - 300 ONE TIME PRODUCERS
GOV. AGENCIES: FOREIGN AND DOMESTIC, NATIONAL, STATE AND LOCAL.
UNIVERSITIES & COLLEGES
CURRICULUM STUDY GROUPS
INDIVIDUALS
ASSOCIATIONS
PRODUCER/ DISTRIBUTOR
15 SIGNIFICANT ORGANIZATIONS
A - V RENTAL LIBRARIES
15 - 20 MAJOR UNIVERSITIES
10 - 20 COMMERCIAL FIRMS
INDEPENDENT DISTRIBUTORS
A - V DEALER (50-100) EACH W/5 - 10 SALESMEN.
REPRESENTATIVES ("MFG. REPS") (A - V) SOFTWARE
DIRECT SALES
RENTAL
MAIL ORDER
DIRECT SALES
RENTAL
MAIL ORDER
DIRECT SALES
RENTAL
MAIL ORDER
EDUCATIONAL COMMUNITY
PUBLIC - SCHOOL BUYING UNITS
NON - PUBLIC SCHOOLS
UNIVERSITIES AND COLLEGES
PUBLIC LIBRARY SYSTEMS

Figure 25. Producer/Distributor Flow

TABLE 50

ANALYSIS OF TITLES BY SUBJECT AREA
(Of Existing Films*) 1966

Subject Area	Primary Grades % of Titles	Intermediate % of Titles	Jr/Sr H. S. % of Titles	College/Adult Teacher - % of Titles
Science	33.0	38.8	37.0	26.9
Social Studies	26.1	40.5	24.0	-
Language Arts	22.2	5.1	8.4	-
Health & Safety	7.1	7.0	6.6	-
Math	5.5	2.4	3.7	-
Guidance	3.9	2.2	9.3	-
Art	2.1	1.9	3.1	5.6
Physical Ed.	0.1	0.2	-	3.0
Music	-	0.9	2.1	1.3
English or Literature	-	-	-	6.5
Foreign Languages	-	1.0	3.2	4.4
Business & Economics	-	-	2.8	6.2
Sociology	-	-	-	13.2
Psychology	-	-	-	4.7
History	-	-	-	9.3
Teacher Ed.	-	-	-	10.9
Vocational & Industrial Art	-	-	-	3.2

* Source -- Five Major Companies

TABLE 51

PRICE VARIATION BY GRADE LEVEL

ITEM	COLOR			B & W		
Grade Level	Avg. Time	Avg. Price	Avg. Pr/min	Avg. Time	Avg. Price	Avg. Pr/min
Primary	12 min	$128	$10.67	12 min	$ 71	$5.92
Intermediate	13	142	10.92	13	72	5.54
Jr/Sr High	14	159	11.36	15	84	5.60
College Adult/ Teacher Ed.	18	207	11.50	19	106	5.58
AVERAGE	14 min	$154	$11.00	15 min	$ 82	$5.47

TABLE 52

PRICE VARIATION BY LENGTH OF TIME

Time Range	Price Range (Color)	Price Range (B & W)
5 - 7 minutes	$ 60 - 80	$ 40
8 - 11	90 - 120	50 - 65
12 - 15	125 - 175	75 - 90

* Source - Analysis of 8,000 film titles of five major companies

Costs also vary for producing film material in a facility which is part of the instructional media system. A representative range for a 20 minute color program is \$8,000 - \$20,000. \$20,000 per 20 minute color program was selected as a representative value when the production of material is subcontracted to a commercial film producing company. \$11,000 was selected as an estimate of the cost of producing a 20 minute color film at the media facility. The number of hours of film material required for each environment is indicated. Using the hypothetical educational task and environmental parameters chosen for this study, alternatives are compared in the following table.

TABLE 53

PRODUCTION COSTS

	Local (1,000 hours)	City (1,200 hours)	Metro (1,300 hours)	State (1,500 hours)	Region (1,600 hours)
\$20,000/ 20 minute program	\$60,000,000	\$72,000,000	\$78,000,000	\$90,000,000	\$96,000,000
\$11,000/ 20 minute program	\$33,000,000	\$39,600,000	\$42,900,000	\$49,500,000	\$52,800,000

Another element which must be considered in estimating production expenses is the cost of the multiple prints of each film. The number of film prints is analogous to channels in a television system. This number is a function of the number of scheduled simultaneous classroom presentations of each program title.

The number of copies of each film is influenced by the instructional and administrative constraints which must be considered in scheduling the presentation of a film. The calendar time period in which an instructional film must be presented is of prime importance and is based on instructional requirements. The amount of time required for the processing of film requests by the AV center must be considered. This processing includes both delivery and pickup of the film, inspecting the film prior to delivery, and the time required for administrative transactions.

To determine the number of prints needed to meet the requirements of the hypothetical educational task, the following assumptions were made.

1. The calendar time period in which a film must be presented is three weeks in length.

2. One film can serve the needs of three schools during the three week period. This includes the processing time required to schedule and deliver the film.

3. Half of the programs required for each environment are for use in elementary school and half are to be used in high schools.

4. The average film program is 20 minutes long.

In addition to these assumptions, the task and environment parameters previously defined were also used in estimating the number of prints. Since it was assumed that half of the programs are for use in elementary schools and the other half in secondary schools and that one film can serve three schools during the required time period, schools in each environment were divided by three and each result was rounded to the next whole number. These results indicate the number of prints needed for each elementary and high school film. For example, in the local environment, the number of elementary and high schools is defined as 14 and four respectively. Dividing by three yields 4 2/3 and 1 1/3. Rounding to the next whole number gives five and two.

Next, the number of program hours needed for each environment was divided by two to determine the number of hours to be used by each elementary or high school. The number of required program hours for each type of school was then multiplied by three to determine the required number of 20 minute film programs. The result of this calculation is 1,500 films.

The next step is to multiply the number of prints of each film needed by the number of required films. This will yield the total number of prints needed for all elementary and high schools. Summing these two numbers yields the total number of prints. For example, the figures for the local environments would be:

5 x 1500 = 7500 prints needed for elementary schools

2 x 1500 = 3000 prints needed for high schools

7500 + 3000 = 10,500 total number of prints

The above calculation may be expressed in the following formula when the total number of program hours has been assumed to be equally divided between elementary and high school requirements.

(Number of prints of each elementary film + number of prints of each high school film) x (Total number of films — 2) = Total number of prints

Using the example:

(5 + 2) x (3000 — 2) = 7 x 1500 = 10,500 prints.

The above word formula was used in estimating the number of prints. When adding the number of prints required for each elementary film and the number of prints required for each high school film, the sums were rounded to 60 for the city, 240 for the metropolitan and 400 for the state environment. The following estimates for each environment were determined.

Environment	Number or Prints
Local	10,500
City	108,000
Metro	468,000
State	900,000

The traditional approach, as indicated earlier, has been to purchase prints from a distribution company. However, if the film has been produced either by subcontracting with a commercial production company or by using a media production facility, then duplication of multiple copies can also be subcontracted to a film processing laboratory or may be duplicated in a laboratory which is part of the educational system. Table 54 compares the cost of multiple prints from each of the following sources.

1. Purchase from distribution company
2. *Contract with film processing laboratory*
3. Use system duplication facility

TABLE 54

MULTIPLE PRINT COST COMPARISON *

Unit Price	Local	City	Metro	State
$200	$2,100,000	$21,600,000	$93,600,000	$180,000,000
40	420,000	4,320,000	18,720,000	36,000,000
15	157,000	1,620,000	7,020,000	13,500,000

*This cost for the regional environment was not estimated, but may be approximated by multiplying total state cost by a factor of 10.

Table 55 summarizes and compares the production and multlple print costs to the cost of acquiring the same number of film programs from commercial distribution sources. The cost of the following options was estimated.

TABLE 55

SUMMARY OF PRODUCTION AND MULTIPLE PRINT COSTS

Option	Unit Price/ 20 Minute Program		Local	City	Metro	State
(1)	$ 200	Purchase	2,100,000	21,600,000	93,600,000	180,000,000
(2)	$11,000	(Production)	33,000,000	39,600,000	42,900,000	49,500,000
	$ 40	(Prints)	420,000	4,320,000	18,720,000	36,000,000
			33,420,000	43,920,000	61,620,000	85,500,000
(3)	$11,000	(Production)	33,000,000	39,600,000	42,900,000	49,500,000
	15	(Prints)	157,500	1,620,000	7,020,000	13,500,000
(4)	$20,000	(Production)	60,000,000	72,000,000	78,000,000	90,000,000
	40	(Prints)	420,000	4,320,000	18,720,000	36,000,000
			60,420,000	76,320,000	96,720,000	126,000,000
(5)	$20,000	(Production)	60,000,000	72,000,000	78,000,000	90,000,000
	15	(Prints)	157,500	1,620,000	7,020,000	13,500,000
			60,157,500	73,620,000	85,020,000	103,500,000

1. Purchase all material from distribution companies.

2. Produce film in media facility and subcontract duplication of prints.

3. Produce film and duplicate prints in media facility.

4. Subcontract both film production and duplication.

5. Subcontract film production and duplicate prints in media facility.

The costs associated with obtaining film prints from the three sources listed above vary greatly. School systems in a local or city environment should try to acquire films to serve their instructional requirements. Schools in a metropolitan area, state, and region should consider producing their own films. This, of course, assumes that the instructional needs are the same throughout the area.

Possible cost savings could be incurred

1. If the school systems cooperate with each other to combine their budgets and offer the commercial companies volume purchases, enough pressure could be brought to bear to reduce the per unit cost of films;

2. If films could be electronically transmitted over closed-circuit TV, the number of multiple copies needed would decrease. Even if individual program costs were increased, cost savings would still result;

3. If schools were allowed to duplicate prints by either of the following two methods, cost savings would occur:

    a. Purchase prints from commercial film laboratories resulting in savings of approximately 50% to 75%, or

    b. Providing the volume of multiple copies required is large enough, a minimal investment of approximately $25,000 for a film duplicating machine + technician's salary + a small facility and film stock would result in a greater savings.

Production as a cost classification in the detailed cost estimate of this report is treated solely as the acquisition of existing films from commercial distribution sources.

From an accounting point of view, an arbitrary decision was made concerning the allocation of multiple copy costs. Multiple copies at current retail prices are allocated to the production category. It can be argued that they could be allocated to the distribution category. Also, volume purchase discounts are not considered although they might be obtained.

Becuase of our treatment of these costs, the bar graphs in the cost comparison section of the report show 16mm film to be much more costly than comparable TV systems.

In this context, therefore, the primary costs associated with production are the costs of the film programs, the duplicate copies needed to achieve the instructional task, and the costs associated with previewing films before purchase.

The costs associated with previewing films were calculated by constructin a representative Film Selection Committee which would preview three times as many hours of program material as are needed. This 2/3 rejection factor is predicated on the audiovisual purchasing practice of some existing school systems. It is assumed that one half of the Committee's previewing time would necessitate a $5 per hour, per person, overtime cost. After applying the formula to various area levels, the previewing cost approximated 10% of the total program cost. The previewing cost is included in the Administration, Training, and Planning category of the cost data sheets which are presented at the end of this section. Only the cost of color programs was used in the model. Black and white programs would cost approximately 40% less.

Distribution

The Audiovisual Center

The audiovisual center is similar to a book library. It has traditionally stored and circulated a variety of instructional materials and devices. These range from 16mm films, filmstrips, slides, transparencies, records and audio tapes to globes, maps, charts, realia kits and all other non-book materials that have required distribution. The facility requirements of the center include ample space for its staff, materials storage, reception area, small production facility for non-16mm film media, and a proper screening area and conference room for evaluation purposes. The location of a center has ranged, in the past, from a floor of an existing school building to a separate facility. Its distribution service has varied widely depending upon the number of schools it has served. No standards have been established relating the center to the number of schools or student population served.

Currently, there are many schools of thought as to where and how media and its equipment should be stored, circulated, etc. Some groups desire a facility in each school building while others promote the concept of a large centralized library. Actually, many of the less expensive media systems such as audio tapes, filmstrips, records, transparencies, etc. could easily be made available on a per building basis. On the other hand, 16mm films, television, and computer systems would require a centralized media center. For the purpose of this study, the facilities costs associated with a 16mm film media center are predicated on the following space requirements based on suggestions made by the Department of Audiovisual Instruction of the National Education Association and the American Library Association.

MEDIA CENTER FACILITIES

SPACE ALLOTMENT

	sq. ft.
Professional	140
AV specialist or assistant	120
Secretary	100
Entrance	400
Film inspectors	100
Technical	100
Graphics	70
Booking clerks	100
Shipping clerks	50
Typing clerks	70
Viewing	400
Rest rooms	70
Repair	200
Conference room	300
Walkways	10%
Film storage	1*

*Multiply by number of film copies.

As these space requirements were applied to the larger environments, it was assumed that multiple media centers would be employed to meet the task assigned to the media system, i. e., regional environments would have a network of media centers to serve the entire geographical area.

A new construction cost of $18. 50 per square foot was used. The entire facilities cost in our model is allocated to the Distribution Capital category. Operating costs for the facility are arbitrarily estimated at 1%.

FACILITY COSTS

ITEM	LOCAL	CITY	METRO	STATE
Audiovisual Center	$71,410	$438,265	$981,425	$3,229,508

Functions of Media Center

The following functions are performed by the center.

- Matching program offerings with teacher needs
- Previewing and evaluating materials and equipment
- Selecting and ordering
- Cataloging
- Inventory dissemination
- Scheduling
- Pickup and delivery to schools
- Repair and maintenance of materials and equipment

Figure 26 is a flowchart showing the order in which these various functions are performed. Curriculum specialists and teachers submit their program requirements to the center. If the films are not readily available, the center will locate the production source. All film acquired for the school area served by the center is previewed and evaluated by a responsible committee. The size and composition of the committee depend upon the size of the school area served and the number of titles in the center. Some schools rely upon the audiovisual director and perhaps his immediate staff to decide which films best fit the teachers' needs while others use the teachers themselves.

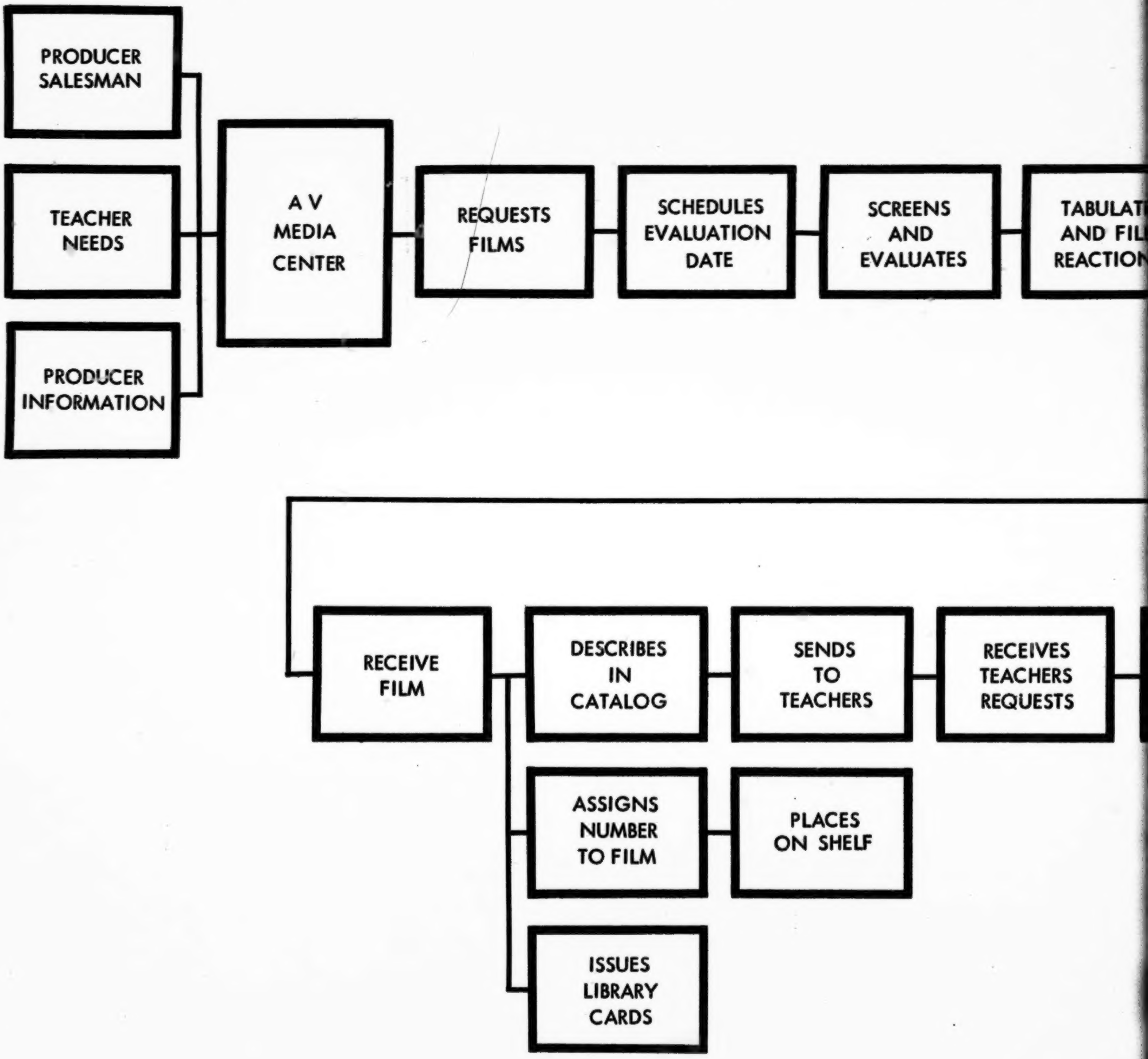
For the purposes of this study, it is assumed that the film evaluation committee consists of:

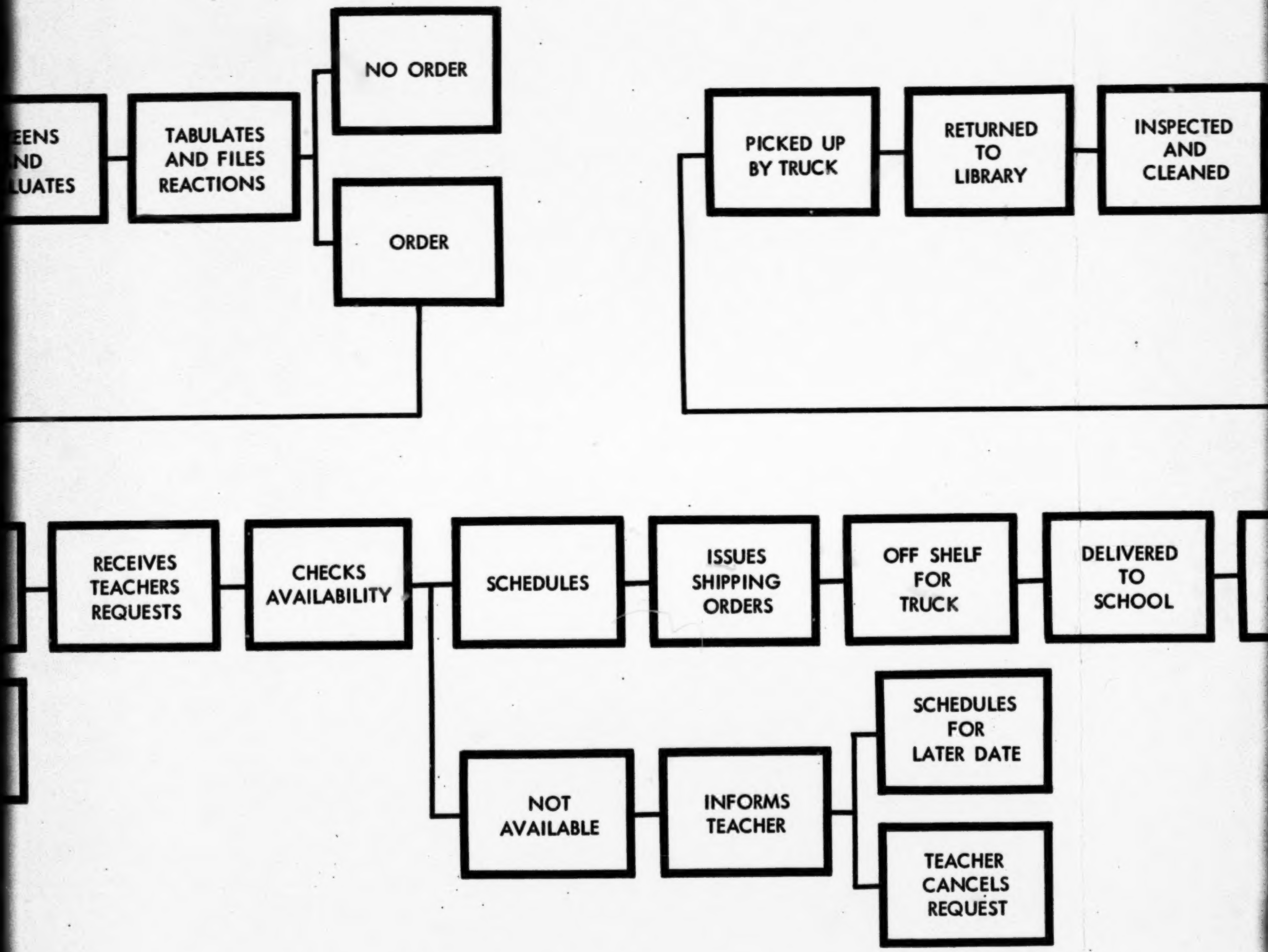
- Teachers
- Subject matter specialists
- Media specialist
- Supervisory education staff
- Appropriate media center staff

The committee would then consider the following type of criteria when screening film program subjects.

Does the subject meet overall learning objectives?

Is film the best medium for presentation?


PRODUCER SALESMAN
TEACHER NEEDS
PRODUCER INFORMATION
A V MEDIA CENTER
REQUESTS FILMS
SCHEDULES EVALUATION DATE
SCREENS AND EVALUATES
TABULAT AND FIL REACTION
RECEIVE FILM
DESCRIBES IN CATALOG
SENDS TO TEACHERS
RECEIVES TEACHERS REQUESTS
ASSIGNS NUMBER TO FILM
PLACES ON SHELF
ISSUES LIBRARY CARDS


EENS
ND
LUATES
TABULATES AND FILES REACTIONS
NO ORDER
ORDER
PICKED UP BY TRUCK
RETURNED TO LIBRARY
INSPECTED AND CLEANED
RECEIVES TEACHERS REQUESTS
CHECKS AVAILABILITY
SCHEDULES
ISSUES SHIPPING ORDERS
OFF SHELF FOR TRUCK
DELIVERED TO SCHOOL
NOT AVAILABLE
INFORMS TEACHER
SCHEDULES FOR LATER DATE
TEACHER CANCELS REQUEST

Figure

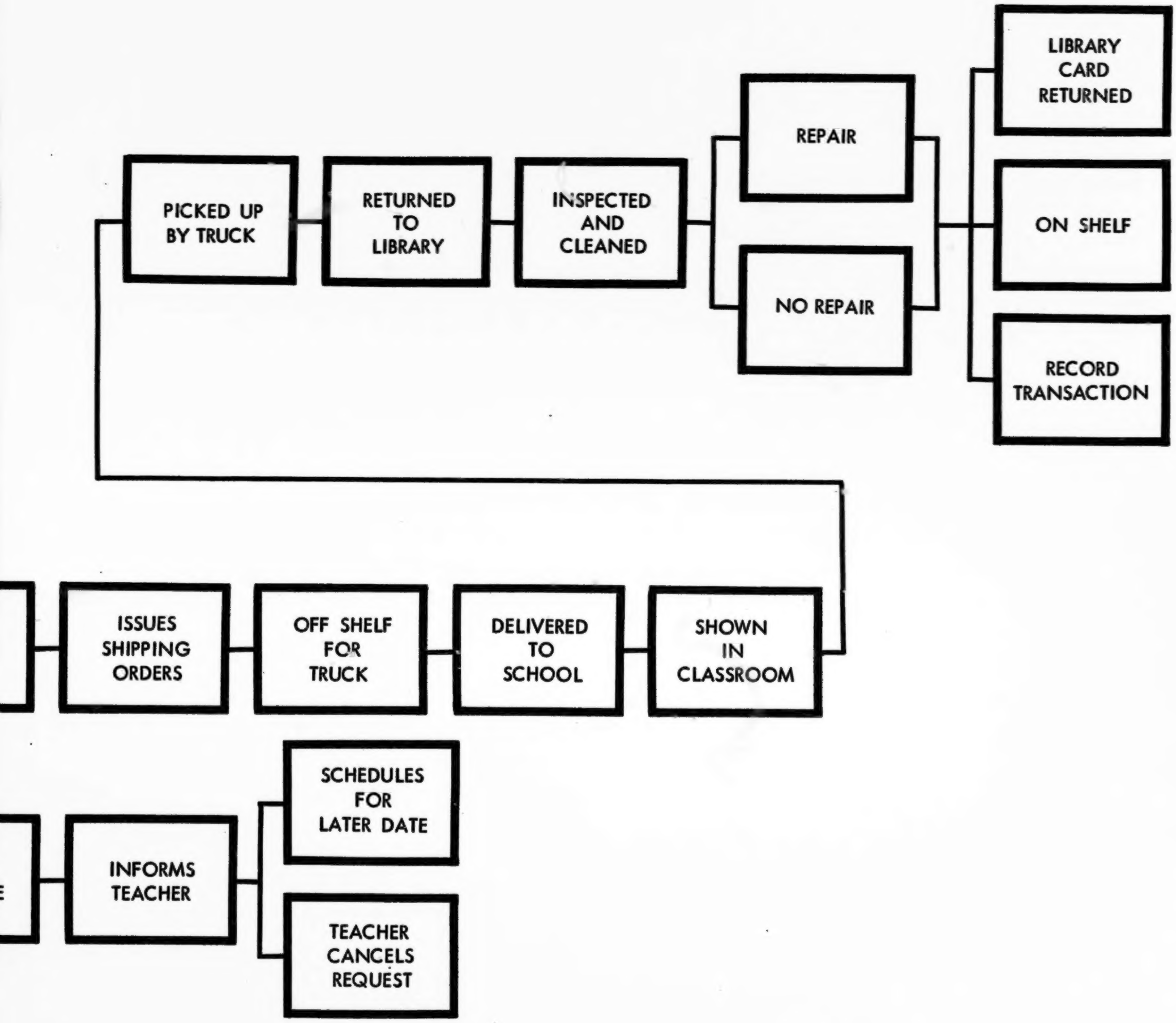

LIBRARY CARD RETURNED
PICKED UP BY TRUCK
RETURNED TO LIBRARY
INSPECTED AND CLEANED
REPAIR
NO REPAIR
ON SHELF
RECORD TRANSACTION
ISSUES SHIPPING ORDERS
OFF SHELF FOR TRUCK
DELIVERED TO SCHOOL
SHOWN IN CLASSROOM
SCHEDULES FOR LATER DATE
INFORMS TEACHER
TEACHER CANCELS REQUEST

Figure 26. AV Media Center Flow Chart

Does the film serve instructional requirements?

Is the film innovative in its treatment of the subject matter?

Are adequate testing and evaluation feasible?

Is the film using modern teaching methods?

After decisions have been reached concerning which film should be purchased, the center's clerical staff expedites purchase orders. When materials are received, they are catalogued, inventoried, and teachers are informed of new acquisitions. Many centers will have a graphic artist on the staff to print and publish a catalog describing the films in their collection. As teachers request specific programs, they are scheduled by a clerical staff. Scheduling is both an art and science, and in some large systems it is done by electronic data processing machines. Most audiovisual centers, however, manually schedule the time at which a film should leave the library to meet a teacher's specific play-date. A clerical staff is also needed to implement the transaction, i. e., removing the film from the shelf and preparing it for delivery. Delivery to the individual school is generally done by a school employee and delivery vehicle. Existing large centers, which are part of many state affiliated universities and serve a large student population or area, will utilize existing postal or independent delivery services. For the purpose of this study, vehicles are utilized to determine delivery costs.

Audiovisual Media Center Staff

The minimum requirements of an audiovisual center are a director and as many administrative, audiovisual specialists as necessary to perform its functions. These personnel would properly oversee the services of the center. Unfortunately, it is difficult to apportion administrative costs to production, distribution, and reception because some audiovisual directors tend to build a good capability in only one or two of these areas rather than in all three. Currently, the Audiovisual Director's Association is attempting to standardize the director's role.

When estimating a staff for an audiovisual center, variables pertaining to school district size and organization structure are of primary importance. Each center should have a director responsible for all of its activities. The number of assistants required depends upon the size of the area served and the manner in which the center is organized. In a smaller district, it is advisable to have at least two media specialists, one each for elementary and secondary grade level films. As a center becomes larger, further delineation of authority and responsibility by function is necessary in order to achieve optimum cost efficiency. Salaries are commensurate with a locale's existing practice and are analogous to other professional classifications (teachers, librarian, etc.). The number of support staff members depends entirely on the volume of transactions of the center.

Information on salaries of media center personnel was gathered by interviewing selected AV directors and consulting the most recent information available at the National Education Association. These figures were averaged and used in our model. The professional, AV specialists and secretaries are considered in the administrative category and allocated on a 30% 40% 30% basis to cost. All other salaries are allocated to the distribution category. All salary costs are treated as operating costs.

DISTRIBUTION STAFF OPERATING COSTS

ITEM	COST
Professional	$10,000
Audiovisual specialist or assistant	8,000
Secretary	5,000
Truck drivers	5,500
Film inspectors	5,500
Technical	8,000
Graphics	7,000
Booking clerks	4,500
Shipping clerks	4,500
Typing clerks	4,500

Equipment

Trucks, electronic film inspection machines, and film storage racks are the most expensive distribution equipment. Other equipment such as desks and minimum test apparatus for repairing projectors is less expensive and was not treated in the model. The number of trucks needed depends upon the number of film deliveries one truck can make per day, the mileage between schools, and the volume of shipments. All equipment costs were determined by checking manufacturer's middle-of-the-line models and averaging their current prices.

TRUCK — OPERATING COSTS

Amortization ($3,500 over 5 years at 5% interest)	$ 810
Maintenance	350
Gasoline consumption (15,000 miles per year)	450
Insurance	250
Total	$1,860

Formulas to determine the number of vehicles and men needed were constructed from information gathered from interviews with AV Directors and film librarians, and from the author's experience.

20 minute delivery per school

3 schools per hour

1 hour driving time, 1 hour lunch

6 hour productive time

1 vehicle = 18 school deliveries per day

Number of schools per area level — 18 =
Number of vehicles needed

Assumptions concerning film shipments were made using sources referred to above.

1 film copy reaches 1 school in 1 week

1 film per day per class to achieve task

8 film programs per day shipped to elementary school

12 film programs per day shipped to high school
(4 grade levels x 3 courses of instruction)

8 x number of elementary schools + 12 x number
of high schools = Total daily shipments

Electronic film inspection machines are needed to clean, treat, and repair films. A film print is generally inspected upon its return to the center after it has been presented in a school. Each machine cleans only a fixed number of prints per day requires a full-time operator. The formula for predicting the number of machines needed is

Assumed output = 8 films per day

Film inspector = 7 productive hour day

1 machine = 56 films per day

Number of daily shipments — 56 = number of men and
machines needed

INSPECTION MACHINE — OPERATING COSTS

Amortization ($3,500 over 5 years at 5% interest)	$ 810
Maintenance	350
Total	$1160

There are only a few models of storage racks from which to choose. These hold a fixed number of prints of long and short programs and require a fixed amount of floor space for easy accessibility. It was determined that a film storage rack occupies 20 square feet of space and holds 200 films.

Number of prints — 200 = Number of racks

Number of racks x $200 = Cost

Space needed = .1 square foot x number of prints

The per unit equipment cost is summarized in the following chart.

DISTRIBUTION EQUIPMENT - CAPITAL COSTS

ITEM	COST
Truck	$3,500
Inspection machine	3,500
Film storage rack	200

The equipment costs for each environment are represented in the following chart.

EQUIPMENT COSTS

ITEM	LOCAL	CITY	METRO	STATE
Trucks	3,500	24,500	98,000	241,500
Inspection	10,500	105,000	430,000	1,228,500
Racks	10,500	99,000	252,000	900,000
Total	24,500	228,500	780,500	2,370,000

Reception

16mm sound projectors have dominated audiovisual media systems since their introduction in the 1930's.

Traditionally, three major companies have been responsible for the growth and development of the units now in use in the educational community. Unfortunately, projectors still have some shortcomings. They require the placement of a reel threaded through the optical and sound mechanism and a take-up reel which is bulky and inconvenient for the teacher to use. Their selling price has been relatively high and skilled personnel is required to maintain the mechanism. These costs have been borne by the educational community. As a result of the impact of Federal funds, projector purchases have been averaging 50,000 units per year during the past few years. Projector engineering and design, however, have not kept abreast of the current state of the art of electronic technology. Nevertheless, due to the large accumulated investment of school systems in nearly 300,000 projectors over the past 30 years, it is hardly likely that a new projection system will replace those now being used. Because of the high per unit cost and audiovisual budget limitations, projectors have to be shared by many classrooms.

Before a teacher-learner can interact with a program, the classroom must have a projection screen, projector, and program on a specific date. Projector and screen costs vary little among manufacturers, and volume purchase offers discount possibilities. Usually, the teacher or a student is adept at operating the mechanism. A technician is required to maintain and repair projectors though these services are also generally available from a local AV dealer. The primary cost determinant, however, is predicated on a somewhat arbitrary decision — the projector to classroom ratio required to perform the educational task. This ratio can be generated from data provided in a school's master schedule. Projectors should be stored in school buildings rather than scheduled and distributed from a center.

The following chart shows this ratio as it now exists in a representative sample of school districts and the ratio suggested by two national educational associations.

NUMBER OF TEACHERS
PER 16MM PROJECTOR ON SCHOOL PREMISES

	IN EXISTENCE[1]					RECOMMENDED	
School Size (teachers)	51-150,	31-40,	21-30,	11-20,	1-10	DAVI[2]	ALA[3]
Elementary	*	18.7,	12.6,	11.0,	7.3	1 per 10 to 1 per 5 (min)	1 per 2
Secondary	12.8,	12.9,	10.2,	8.5,	6.4		

* There were no elementary schools with more than 50 teachers in the sample.

[1] The State of Audiovisual Technology: 1961-1966, by Eleanor P. Godfrey, National Education Association, Department of Audiovisual Instruction, 1967.

[2] Quantitative Standards for Educational Media, Personnel, Materials, Equipment and Facilities, Department of Audiovisual Instruction of NEA

[3] American Library Association

Reception Costs

In determining reception costs, $670 are used as the price of a 16mm film projector and a mobile stand. It was assumed that there would be one projector and stand for every two classrooms. The other major cost factor is the screen. Portable screens were not considered even though their prices are comparable to a permanently mounted wall model. The reception costs were calculated assuming that each classroom would have a wall model at a cost of $60. Other costs such as wiring, electricity, light dimming devices or special shades are not treated. Teacher-student operating costs and classroom facility costs are not included in the model.

The projector equipment represents the largest capital investment in the reception cost category. Maintenance costs are calculated at 10%.

The following chart shows the costs of reception equipment in the various environments.

ITEM	LOCAL	CITY	METRO	STATE
Projector	$147,400	$1,527,600	$6,110,400	$10,278,000
Screen	26,400	273,600	1,094,400	1,888,000
Total	$173,800	$1,801,200	$7,204,800	$12,166,000

Other Costs

In formulating the model, costs for salaries, equipment, and previews, as well as formulas relating to production, distribution and reception were kept constant on each of the five levels of application. This method allowed per student costs to be treated in a more equitable manner. It was also recognized that minimal cost efficiencies would accrue in larger areas because of discounts with volume purchasing.

Teacher Training, Planning, Administrative (except for Salaries), and Related Materials costs were calculated by using the same formulas as those described in the television section of the report. Research and Evaluation was assumed to be $.10 per student.

Amortization rates in our model were as follows:

5 Years .231	Film Programs Projectors Vehicles Film Inspection Machines
10 Years .129	Other Equipment Maintenance Administration and Planning Teacher Training
25 Years .071	Media Center Facilities

Cost Data Sheets

The following pages are the collection of costs for the 16mm film media system. They are arranged within each category, production, distribution, and reception, and for each level of application. The costs were collected using the formulas in the preceding descriptions. Following the cost data sheets is a table presenting per pupil cost data.

TABLE 56

16 MM — LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		
Equipment and Facilities		
Administration, Training, and Planning	$ 222,750	$13,575
Programs and Materials	2,100,000	
Research and Evaluation		
Total:	$2,322,750	$13,575

Equivalent Annual Cost $548,830

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$57,000
Equipment and Facilities	$ 95,910	3,399
Planning	17,000	
Administration and Training	4,666	17,955
Total:	$117,576	$78,354

Equivalent Annual Cost $91,878

RECEPTION	CAPITAL	OPERATING
Teacher Training	$120,000	$22,250
Equipment	173,800	26,678
Administration and Planning	13,416	20,522
Related Materials		6,600
Research and Evaluation		1,500
Total:	$307,216	$77,550

Equivalent Annual Cost $134,908

TABLE 57

16 MM — CITY

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		
Equipment and Facilities		
Administration, Training, and Planning	$ 2,181,000	$52,200
Programs and Materials	21,600,000	
Research and Evaluation		
Total:	$23,781,000	$52,200

Equivalent Annual Cost $5,543,470

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$400,500
Equipment and Facilities	$666,765	29,518
Planning	28,000	
Administration and Training	32,792	77,730
Total:	$727,557	$507,748

Equivalent Annual Cost $599,490

RECEPTION	CAPITAL	OPERATING
Teacher Training	$1,020,000	$252,500
Equipment	1,801,200	273,732
Administration and Planning	23,666	82,988
Related Materials		68,400
Research and Evaluation		15,000
Total:	$2,844,866	$692,620

Equivalent Annual Cost $1,243,330

TABLE 58

16 MM — METRO

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		
Equipment and Facilities		
Administration, Training and Planning	$ 9,415,500	$161,550
Programs and Materials	93,600,000	
Research and Evaluation		
Total:	$103,015,500	$161,550
Equivalent Annual Cost	$23,952,470	

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$1,586,500
Equipment and Facilities	$1,761,925	95,669
Planning	74,000	
Administration and Training	129,875	251,292
Total:	$1,965,800	$1,933,461
Equivalent Annual Cost	$2,209,738	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 4,020,000	$1,010,000
Equipment	7,204,800	840,528
Administration and Planning	66,166	287,555
Related Materials		273,600
Research and Evaluation		60,000
Total:	$11,290,966	$2,471,683
Equivalent Annual Cost	$4,663,107	

TABLE 59

16 MM — STATE

PRODUCTION	CAPITAL	OPERATING
Personnel and Supplies		
Equipment and Facilities		
Administration, Training and Planning	$ 18,150,000	$258,000
Programs and Materials	180,000,000	
Research and Evaluation		
Total:	$198,150,000	$258,000

Equivalent Annual Cost $46,015,350

DISTRIBUTION	CAPITAL	OPERATING
Personnel and Supplies		$3,187,500
Equipment and Facilities	$ 5,599,508	292,995
Planning	200,000	
Administration and Training	261,708	411,236
Total:	$6,061,216	$3,891,731

Equivalent Annual Cost $4,728,056

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 6,720,000	$1,681,600
Equipment	12,166,000	1,578,260
Administration and Planning	167,333	456,777
Related Materials		462,000
Research and Evaluation		100,000
Total:	$19,053,333	$ 4,278,637

Equivalent Annual Cost $7,977,449

TABLE 60

COSTS PER PUPIL -- 16mm FILM SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$154.85	$ 0.90	$ 7.84	$ 5.22	$20.48	$ 5.17	
Equivalent Annual Cost	$36.59		$6.13		$ 8.99		$51.71
CITY	$158.54	$ 0.35	$ 4.85	$ 3.38	$18.97	$ 4.62	
Equivalent Annual Cost	$36.96		$ 4.00		$ 8.29		$49.25
METRO	$171.69	$ 0.27	$ 3.28	$ 3.22	$18.82	$ 4.12	
Equivalent Annual Cost	$39.92		$ 3.68		$ 7.77		$51.37
STATE	$198.15	$ 0.26	$ 6.06	$ 3.89	$19.05	$ 4.28	
Equivalent Annual Cost	$46.02		$ 4.73		$ 7.98		$58.73
REGION							
Equivalent Annual Cost							

SECTION D

EDUCATIONAL RADIO

EDUCATIONAL RADIO

Introduction

Radio was first used in the education field at the University of Wisconsin in 1918. However, radio has not been utilized by educators in this country to the same extent as have the other media. Even though there are presently over 300 educational broadcast licenses, the average amount of broadcast time per station is low. The majority of the stations broadcast "enrichment" programs, and very few instructional materials have been developed. In contrast, other countries have utilized radio very effectively.

Radio can play a significant role in the educational field. Courses ranging from language and economics to science and history have proved to be excellent subjects for this medium.

There are, however, significant changes to be made before educational radio can have national coverage and impact. There is an uneven distribution of educational radio stations across the country. The northeast quadrant, Great Lakes region, and the major cities of the West and Pacific Coast are covered adequately, but there are not a sufficient number of stations in the Southeast, Southwest, Plains, and Rocky Mountain states. The FCC is considering various ways of filling this gap since it is primarily a problem of spectrum allocation. Another factor which has limited the growth of educational radio is the dearth of available instructional programming. The largest organization which supplies radio programming, the National Educational Radio Network (NERN), distributed some 33,855 hours of educational programming across the United States on a total operating budget of $65,000 in 1967. It is evident that a much larger supply of instructional material for radio must be available before this media can be used extensively.

Several separate configurations are considered in this report: single channel FM broadcast; multiple channel broadcast using multiplex techniques; and the EDUCASTING* system. Since the production costs are usually independent of the distribution system, they are first discussed without reference to a particular distribution system. The exception is production for multiple channel broadcast which uses all the channels simultaneously as parts of the total program. The distribution and reception costs are then discussed by application level (local city school district, city schools, metropolitan area, state, and region). This is followed by a discussion of the costs which apply across the categories. Finally, a set of cost data sheets brings together the costs for three of the systems at each application level.

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*EDUCASTING is the trademark of TuTorTape Laboratories Inc. (44)

Production

The materials used on educational radio are the most important components of the system, and the costs of producing them are the most difficult to establish. There is little published data reflecting actual programming expenses for radio.

Cost of Good Quality Materials *

Assuming the existence of a demonstration production facility with optimal conditions, the following is an estimate of the cost of a 20 minute audio series of 75 lessons produced during one year.

Teacher	$ 9,000
Content specialist	7,000
Writer for printed materials 1/2 time	4,500
Measurement specialist	7,500
Evaluation expenses	2,500
Studio production costs ($231/lesson)	17,325
	$47,825
Overhead (20%)	9,565
	$57,390
	$765/lesson $2295/hour

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* These costs parallel the production costs of television materials. Most existing audio instructional materials has been produced through the efforts of radio stations generating materials for local use. In this study, it was determined that no production facility now exists that develops materials at the level used in the model. There are plans for such an effort, however.

The $231 per lesson cost for studio production is derived as follows, assuming five courses can be prepared in one studio.

Studio Production Costs - Radio	
Producer-Director 1/2 time	$ 4,500
1 Audio Engineer 1/5 time	2,000
Audio tape for 75 lessons ($25 per 20 minute tape 2-1 usage factor)	3,750
Talent, prerecorded sound, and incidentals @ $15/lesson	1,125
Capital Equipment	
Console, microphones, professional turntables and styles, tape recorders and accessories - original cost - $7,750	
Studio, control room, and auxiliary construction - 1,000 sq. ft. @ $25/sq. ft. - $25,000	
Amortization on equipment	1,000
	$12,375
Overhead (40%)	4,950
	$17,325
	$231/lesson $693/hour

Minimum and Maximum Costs

Another type of cost estimate would be the minimum cost of producing materials. For radio, this means a teacher's salary and a minimal studio run by students. Itemization of the significant costs is listed below.

Assume, 20 minute lessons, one per day. 5 x 36 = 180 lessons = 60 hours. Studio produces five courses per day.

Teacher annual rate	$ 8,000
Materials $11/lesson	1,980
Producer-Director 1/5 x $10,000	2,000
1 sound technician, 1/5 x $3,000	600
Depreciation on equipment	400

$\frac{\$12,980}{60 \text{ hours}}$ $216/hour

20% overhead = $43
per hour cost = $259

The cost of a maximum effort is limited only by the ability to assemble and control the resources being used. If radio's potential were exploited to the fullest, the teacher might be provided, for example, with an audio console which could call forth a wide variety of auditory sequences based on the moment to moment classroom situation. Probably many of the present limitations of instructional radio could be overcome if an effort were made to depart from the present temptation to use a pre-media classroom format. If the knowledge gained from learning theory and practice were used as a course was prepared, pretested, and reformulated as necessary, it is again likely that a much more effective lesson or other educational material segment could be produced. The costs of such maximum effort materials might be very high, perhaps $9,000 to $20,000 per hour. Compared to the $259 minimum and $2,292 high quality figures, these costs seem quite high. Some experimentation on this level should be attempted. However, the figures are not useful for the major thrust of this portion of the study, which is mainly focused on present educational patterns.

Prerecorded Materials

By recording lessons on audio tape, they can be used repeatedly. Of course, portions of certain subject matter would become obsolete in time. It is usually assumed that instructional materials not specifically oriented to current events can be used for roughly three to seven years within a school system. Since recording usually will cost only a very small fraction of the cost of producing the materials, there are considerable savings in recording and reuse. This study allows for this savings by assuming a lesson is used for an average of five years. The cost figures assume that the material for one year is available at the inception of the system. Each year 1/5 of the original cost is spent replacing or updating these materials.

Greater use of the materials can be achieved by distributing additional copies of the recorded materials to other school systems or instructional media distribution systems. Again, making copies is much cheaper than producing the original material, and considerable savings can be achieved. Indeed, if a sufficient supply of original materials were available, we could merely show a rental or copy cost for production rather than the original cost, much as would be done for textbooks. Unfortunately, there are no sources of supply which have the amount of material which has been specified in this study.

Audio instructional materials are recorded with a tape recorder and associated studio equipment. Because the original recording must be of the highest quality, the recording should be done on a professional quality recorder costing $4,000 to $7,000. The duplication of additional copies is again performed on a professional quality duplicator, which will make a number of copies simultaneously, unless only short-term local use is planned. Therefore, the cost of the copies is the amortized cost of the equipment, the operator's salary, and mailing costs.

Existing National Educational Radio Organizations

National Educational Radio Network (NERN). The National Educational Radio Network is an organization of 150 educational radio stations which have banded together to create a national distribution center. Most of the programs are produced by the member stations and NERN acts as a duplication and distribution center. It is a self-supporting operation through member fees. In 1967, they had distributed 33,855 hours of programming with an operating budget of $65,000.

Broadcasting Foundation of America. Distributor for overseas programs to U. S. stations.

Eastern Educational Radio Network. A group of eight eastern radio stations which exchange taped programs, cooperate in program production, and have a capability for live interconnected programs.

Intercollegiate Broadcasting System. This is an organization which provides an average of 4 3/4 hours of taped material per week. The material comes from member stations and the British and Canadian Broadcasting Corporations.

National Programming Source

Programming for instructional radio, particularly "high quality" programming, can be a cost problem for the local school districts. The obvious answer is to cooperate with other schools in broadcasting the materials to reduce the cost per student. But scheduling becomes a problem as more systems with diverse schedules and programming needs are covered by one broadcast. If the local school could obtain programming at minimal cost, greater scheduling flexibility would result.

To provide materials for the local schools at a minimum cost would require

- Vastly increased production of programs designed for national usage;
- A national or regional tape duplication center to provide copies at a low cost. (The existing NERN facility is a prototype.);
- Vastly increased use of the materials in the schools so that amortization of the original production cost becomes negligible;
- Freedom of the schools to make unlimited copies and transcriptions, perform modifications, and add to the materials.

Funds for production of materials could be supplied by various Federal, foundation, industry, and other agencies to

- Local schools for better programming production in science, etc. just as NDEA funds are used to buy films, etc.,
- Local ETV stations which would act as production centers and coordinators for local schools in their area,
- State departments of education,
- OEO programs in vocational education,
- Scientific and other interest groups, National Tape Repository, etc., and ethnic and cultural groups.

The national duplication facility is available already in limited form. The copyright problem may be substantial, but the funding could contain provisions for free use.

Tables 61 to 63 show the calculation of the cost of programming for the various size instructional radio systems used in this study. Three separate types

TABLE 61

MINIMUM PRODUCTION COSTS - RADIO

Application Area	Hours	% Rent	Cost/Hour	Sub.Total	% Produce	Cost/Hour	Sub. Total	Total
Local	1000	1/2	$14.50	$7,250	1/2	$259	$129,500	$136,750
City	1200	1/4	$14.50	$4,350	3/4	$259	$233,100	$237,450
Metropolitan	1300	1/4	$14.50	$4,713	3/4	$259	$252,525	$257,238
State	1500	1/4	$14.50	$5,438	3/4	$259	$291,375	$296,813
Region	1600	1/4	$14.50	$5,800	3/4	$259	$310,800	$316,600

TABLE 62

HIGH QUALITY PRODUCTION COSTS - RADIO

Application Area	Hours	% Rent	Cost/Hour	Sub. Total	% Produce	Cost/Hour	Sub. Total	Total
Local	1000	1/4	$14.50	$3,625	3/4	$2,295	$1,721,250	$1,724,875
City	1200	1/4	$14.50	$4,350	3/4	$2,295	$2,065,500	$2,069,850
Metropolitan	1300	1/4	$14.50	$4,713	3/4	$2,295	$2,237,625	$2,242,338
State	1500	1/4	$14.50	$5,438	3/4	$2,295	$2,581,875	$2,587,313
Region	1600	1/4	$14.50	$5,800	3/4	$2,295	$2,754,000	$2,759,800

TABLE 63

NATIONAL PROGRAMMING SOURCE - PRODUCTION COSTS

Application Area	Hours	National Production and Distribution Costs @ $10/hour
Local	1000	$10,000
City	1200	$12,000
Metropolitan	1300	$13,000
State	1500	$15,000
Region	1600	$16,000

of costs are given: minimum cost, high quality cost, and cost from a national programming source.

The minimum cost is based on the $259 per hour live production figure suggested above and the rental of a fraction of the materials at $14.50 per hour. As the systems become larger, more tapes are needed because of greater student need. The proportion of rented tapes declines since the larger system can more easily afford to develop its own materials.

The high quality materials costs are based on $2,295 per hour as suggested above and on the $14.50 per hour rental figure. It is assumed that 1/5 of the materials are replaced each year.

The national programming source costs are based on the eventual reduction of the $14.50 cost to $10/hour with widescale usage. The programming costs are used as one portion of the production category of costs.

A model NERN facility with $45,000 of new tape equipment (Ampex series 3200 with 10 duplicators) would furnish 1600 tapes per week on an operating budget of $65,000. If amortized at $5,000 per year, the facility would have the $2.70 per hour tape reproduction cost quoted earlier. For the purposes of this model, we have assumed the total cost per hour to be $14.50 which would allow some $12.00 per hour toward production costs. Assuming 100 stations and 100 copies of each tape distributed, then the following breakdown occurs.

Tape and tape handling costs	$ 4.40
Reproduction costs (NERN figures do not include total tape costs)	2.10
Programming costs	8.00
	$14.50

The costs for minimum programming are used on the cost data sheets at the local and city level because high quality materials are too expensive on a per student basis at these levels.

For purposes of comparison with other media systems, Tables 61 and 62 present estimates for a four-channel radio system. Because of the limited capability of a single channel system, it would be unrealistic to estimate costs based on the same number of program hours which are hypothesized in the model. Therefore, the cost estimates for programs produced by the system in Tables 61 and 62 are reduced by 50% for the single channel system. The cost of rentals remain unchanged.

Distribution

Three educational radio distribution systems are described and costed - single channel broadcast, multiplex broadcast, and "EDUCASTING" broadcast. This description is followed by a discussion of radio relay networks.

Single Channel Broadcast

FM radio services are categorized by the FCC into Class A, B, or C according to the size and population of the area it is to serve.

A Class A station is designed to render service to a relatively small community and the surrounding rural area. The coverage of a Class A station is obtained from a transmitter which does not exceed three kilowatts effective radiated power and antenna height of 300 feet above average terrain.

A Class B station is designed to render service to a sizable community, city, or town or to the principal city or cities of an urbanized area and to the surrounding area. The coverage of a Class B station is obtained from a transmitter which does not exceed 50 kilowatts effective radiated power and antenna height of 500 feet above average terrain.

A Class C station is designed to render service to a community, city or town and large surrounding areas. The Class C station has a coverage which does not exceed that from 100 kilowatts effective radiated power and antenna height above average terrain of 2,000 feet.

Multiple Channel - Multiplex Broadcast

Perhaps the most important technological development in educational radio is multiplexing, which has opened up almost endless possibilities for service to small, specialized audiences. Indeed, if the hopes of educational broadcasters are realized, sideband broadcasts will penetrate into every aspect of modern life.

Multiplexing permits one or more signals (subcarrier) to be carried "piggy back" on main channel transmission. It is not a new device but has had a long and useful history in telephony and extensive military utilization in situations where simultaneous multiple transmission is needed.

In FM broadcasting this unique form of multiplexing allows for additional program channels along with the regular audio. The subchannel is transmitted by means of an interleaving with the main channel broadcast along with a subcarrier frequency which is used to extract the subchannel at the receiver.

Its widest and best known use in broadcasting has been in stereo transmission. Most recently it has been used as a device to provide additional private point-to-point communications capacity for educational and commercial broadcasters. The multiplex signal can be received only by a special multiplex receiver or adapter (the adapter as distinguished from the receiver uses the tuning circuits of an FM receiver and its power amplifier) tuned to one of several frequencies permitted under Subsidiary Communications Authorization (SCA) from the Federal Communications Commission.

The possible number of subchannels, with monophonic transmissions, is eight on Class B and C stations and six on Class A stations. With stereophonic transmissions Class B and C stations can transmit three subchannels, and Class A stations, one subchannel. If the SCA subchannel, as now used, is transmitted with 15 percent deviation of the main carrier, Class B and C stations can transmit five additional subchannels and Class A stations, three subchannels.

The results of this and similar experiments have shown that the use of frequency division multiplexing techniques in connection with present commercial FM broadcast stations offers great potential for adding educational broadcasting channels.

EDUCASTING Broadcast

EDUCASTING is an existing commercially available service which presents a rental or lease alternative and can be compared with the four-channel multiplex system considered above. EDUCASTING is a new, patented method of instruction using three FM subcarrier channels to transmit responses to students' answers, and the main channel to transmit questions and course materials. The necessary transmitting equipment plus receivers are leased at an annual cost of $7,500. This fee includes installation and "system supervision during the initial stages". If course material is supplied by others in finished script form, the Triangle Stations (4100 City Line Avenue, Philadelphia, Pennsylvania) will record it on a four-track tape at a price of $75 per hour which includes the recording talent, time, and the cost of a master tape. Several EDUCASTING courses are presently available on a royalty basis of $15 per course per student. Pictures, charts, diagrams, and text are included in the "Edu-text", a combination textbook and workbook supplied to each student. The four channels of EDUCASTING are all programmed parts of one lesson. They are fed to a modulator by a four-track recorder and then to the transmitter. Therefore, the operating costs are less than the separate four-channel multiplex system. The production costs are difficult to estimate and it is assumed that they are no more than for the separate four channels of programming.

In order to compare the EDUCASTING distribution technique to the single channel system, a $7,500 increment has been added to the distribution equipment annual operating cost of the latter system.

Cost Analysis of the Radio Distribution System

Single Channel Broadcast. The normal FM station system consists of a studio and production facility, a transmission site and transmitter, and the various FM receivers in schools and in the home. The production studio, its personnel and supplies, equipment and facilities, its program production, and the evaluation of program effectiveness and audience size were costed under the program production discussion. The distribution component consists of a transmitter and transmitter building, the antenna system with a tower, and corresponding control and test equipment.

The basic configuration is described here along with equipment, personnel, and supply requirements for each of the application levels - local, city, metropolitan, state, and regional. The EDUCASTING system is costed only at the metropolitan and larger areas.

Local

The distribution system is a 10 watt (or, alternately, a low-powered) FM station, with short coverage (two to five miles). The 10 watt system is typical of many existing educational stations which are recognized as minimally adequate. The capital equipment cost includes the cost of transmitter, antenna, modulator, and frequency monitor. (FM transmitter, with 100% tube and spare parts kit, $1,695; antenna, $400; transmitter block, $2,000). The planning cost is for an engineering survey to obtain a construction permit. Maintenance is assumed to be performed by one engineer who also maintains the audio production equipment.

City

The costs are based on a 250 watt transmitter. The cost breakdown follows.

Transmitter	$ 6,000
Additional equipment and spares	2,000
Antenna, tower, transmission line (300 ft. tower)	40,000
Transmitter building	8,000
Installation fee	5,000
	$61,000

Maintenance is performed by two engineers part time.

Metropolitan

The cost breakdown is

Transmitter 25 kw	$ 55,000
Tower, antenna, transmission line	66,000
Transmission building	14,000
Installation fee	10,000
	$145,000

The costs above are for single channel equipment (14, 15). Multiplex equipment would add a small amount to these costs. An estimate is added in the cost data sheets.

State

The system for a state includes 10 metropolitan level FM stations and an interstate radio relay network.

Region

The single channel radio system for the region is simply taken as 10 times the state system.

Radio Relay Network. VHF-FM radio relay has been demonstrated since the early days of FM broadcasting. Programs were passed from station to station over a considerable distance with good quality. Several groups of commercial FM stations formed small loosely knit networks. An early example was developed for a rural radio network in the State of New York. It linked six stations in the central part of the State covering approximately 265 airline miles between stations and serving 118,000 farms.

About the same time, networks appeared to relay sporting events. However, with the rapid advance of television and its network coverage, FM radio relay techniques never reached full maturity.

A radio system seeks to provide maximum usefulness at a minimum operating cost. A first requirement is an adequate signal level throughout the area served as well as to the receiver at the repeater point. Terminals must then be strategically located to provide a usable signal. Interference is kept low by carefully selecting proper frequencies.

Network methods to minimize cost have been considered by the National Bureau of Standards in a study performed as part of this cost study. The NBS considered an FM relay network for the State of Colorado. Covering approximately 300 airline miles, it extends from Trinidad in the South through Walsenburg, Pueblo, Colorado Springs, Denver, Loveland, and to Cheyenne, Wyoming. Remote control of repeater sites is assumed to eliminate the need for operators at each relay point. Repeater stations are located every 50 miles which would require a minimum of two sets of terminal equipment if through channels exist for Trinidad and Cheyenne. A maximum of seven sets of terminal equipment is required if communication channels exist at each of the cities above. Two-way channels are assumed.

Table 64 provides a cost comparison of Telpak, private wire, and FM radio relay services for a common carrier using the following rates.

Rates-Voice Channel - per mile	
Telpak	$0.45/mile/voice channel
Private wire	$2.02/mile, 1st 250 miles
	$1.717/mile, 251-500 miles

Another fixed monthly expense for Telpak and private line common carriers is a local channel charge of $12.50 and channel terminal charge of $17.50 per terminal for three KHz telephone circuits.

The following conclusions were reached by the NBS study group regarding voice communication and data.

- A radio relay system will cost less than leased facilities.
- No change in the comparative cost of Telpak and radio relay occurs as the number of channels increases.
- There is a decrease of comparative cost for Telpak over radio relay when the number of terminals increases.
- As the number of channels increases, private line rates begin to compete with Talpak.

Reception

The cost for each individual school must be computed before the actual reception equipment costs for a school district can be determined. The costs vary with the size of each school. An average cost per school can be obtained which would produce a fairly accurate cost extrapolation over areas larger than a single school district. This study will use an average cost for a small school (elementary) and an average cost for a larger school (junior or senior high). This method is used to illustrate that some costs vary with the number of sets in use, and some costs are somewhat independent of this number.

The enrollment of the smaller school is 500 to 700 students. It contains 20 or more classrooms and each will be provided with radio reception equipment.

The larger school's enrollment is 1000 to 15000 students. It contains 40 or more classrooms. Thirty-five rooms will be provided with radio receivers which are portable and can be used in the other rooms.

TABLE 64

Tabulated Monthly Cost for Voice Channel (250 - 3200 Hz) Communications*

# Chan.	# Term.	Total Distance	Rate x Distance x # Chan.	# Term. x Fixed Expense x # Chan.	Mo. Total
			Telpak		
1	2	300 Miles	$0.45 x 300 x 1 = $135	2 x $30 x 1 = $ 60	$ 195.00
1	7	300 Miles	$0.45 x 300 x 1 = $135	7 x $30 x 1 = $ 210	$ 345.00
5	2	300 Miles	$0.45 x 300 x 5 = $675	2 x $30 x 5 = $ 300	$ 975.00
5	7	300 Miles	$0.45 x 300 x 5 = $675	7 x $30 x 5 = $1050	$1725.00
			Private Line		
1	2	300 Miles	($2.02 x 250 + $1.717 x 50) x 1 = $ 590.85	2 x $30 = $ 60	$ 650.85
1	7	300 Miles	($2.02 x 250 + $1.717 x 50) x 1 = $ 590.85	7 x $30 = $ 210	$ 800.85
5	2	300 Miles	($2.02 x 250 + $1.717 x 50) x 5 = $2954.25	2 x $30 = $ 60	$3014.25
5	7	300 Miles	($2.02 x 250 + $1.717 x 50) x 5 = $2954.25	7 x $30 = $ 210	$3164.25

Radio Relay
(Purchase Multiplex Equipment)

# Chan.	# Term.	Total Distance	Cost	Equivalent Annual Cost **	Mo. Total
1	2	300 Miles	2 x $2000 = $ 4,000	$ 4,000 x .149 = $ 596	$ 49.67
1	7	300 Miles	7 x $2000 = $14,000	$14,000 x .149 = $ 2,086	$173.83
5	2	300 Miles	10 x $2000 = $20,000	$20,000 x .149 = $ 2,980	$248.33
5	7	300 Miles	35 x $2000 = $70,000	$70,000 x .149 = $10,430	$869.17

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* Reproduced from Applications of Multiplex Channels. (195)

** Based on 10 year life and 8% interest.

Radio receivers are the basic reception equipment in all of the radio systems.* To the cost of the receiver is added the particular equipment costs which vary from system to system. Thus, the difference in reception equipment costs for each system consists mainly of the difference in antenna, amplifier, and distribution costs for each system.

Included in the hardware costs are the costs of installation, sighting of antennas, and system checkout. All reception costs for multiplex equipment are based on four-channel operation and are dependent upon widescale future distribution of multiplex receivers. The EDUCASTING receiver, however, is available at the present time. All equipment costs, with the exception of the multiplex system, are based on current prices.

The basic cost for a single channel receiver is $50 including antenna, and incorporates an above average audio amplifier and speaker arrangement. The four-channel multiplex receiver is priced at $75 and has the capability to reproduce a channel at a time in response to a student's or teacher's request.

It is assumed that one half of the schools use a central receiver and amplifier, and distribute the audio material to the individual classroom over a public address system, while the remainder of the schools use individual receivers in the classroom. The following is an example of this basic cost for an elementary school in a school district of medium size which uses single channel receivers.

Receivers for 20 classrooms in seven schools	$ 7,000
Central amplifier for seven schools @ $250 along with $850 with distribution system	7,700
Total	$14,700

Cost Data Sheets

The following pages are cost data sheets which collect the costs in each category of production, distribution, and reception for each educational radio system and in each area of application. These costs were obtained from the preceding descriptions.

The equivalent annual cost listed on the cost data sheets is a combination of the annual operating cost and amortization of the capital cost.

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*In this study, it was assumed that the base cost for a radio receiver would be $50. American (GE, Elgin) and foreign manufacturers are already producing high quality AC/battery operated FM receivers with 10 - 12 transistors and 2 - 3 inch speakers. In large quantities, these receivers would probably be available for half the price ($25).

TABLE 65

SINGLE CHANNEL RADIO

LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		
Equipment & Facilities	$12,400	2,000
Administration Training & Planning	2,000	
Programs & Materials	64,750	9,200
Research & Evaluation		1,500
Total:	$79,150	$12,700
Equivalent Annual Cost	$29,515	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 1,500	$12,000
Equipment & Facilities	8,500	3,000
Planning	1,200	
Administration & Training	300	3,000
Total:	$11,500	$18,000
Equivalent Annual Cost	$19,484	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$10,000	$ 4,400
Equipment	23,000	
Administration & Planning	1,000	2,500
Related Materials		11,000
Research & Evaluation		5,500
Total:	$34,000	$23,400
Equivalent Annual Cost	$27,786	

TABLE 66

SINGLE CHANNEL RADIO

CITY

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		
Equipment & Facilities	$ 17,500	2,000
Administration Training & Planning	6,500	1,000
Programs & Materials	116,550	17,850
Research & Evaluation		4,000
Total:	$140,550	$ 24,850
Equivalent Annual Cost	$ 54,869	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies		$ 20,000
Equipment & Facilities	$ 61,000	3,000
Planning	2,000	
Administration & Training	2,000	2,500
Total:	$ 65,000	$ 25,500
Equivalent Annual Cost	$ 33,885	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 12,000	$ 45,600
Equipment	202,000	2,000
Administration & Planning	2,000	15,500
Related Materials		114,000
Research & Evaluation		15,000
Total:	$216,000	$192,100
Equivalent Annual Cost	$219,964	

TABLE 67

SINGLE CHANNEL RADIO

METROPOLITAN

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 5,000
Equipment & Facilities	$ 29,500	
Administration Training & Planning	8,000	20,000
Programs & Materials	1,118,812	29,000
Research & Evaluation		5,500
Total:	$1,156,312	$ 59,500
Equivalent Annual Cost	$ 322,800	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 4,000	$ 35,000
Equipment & Facilities	145,000	15,000
Planning	4,000	2,000
Administration & Training	3,000	31,000
Total:	$156,000	$ 83,000
Equivalent Annual Cost	$103,100	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 18,000	$182,400
Equipment	906,000	9,000
Administration & Planning	3,000	92,000
Related Materials		182,000
Research & Evaluation		50,000
Total	$927,000	$515,400
Equivalent Annual Cost	$635,000	

TABLE 68

SINGLE CHANNEL RADIO

STATE

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 10,000
Equipment & Facilities	$ 100,000	
Administration Training & Planning	12,000	
Programs & Materials	1,290,938	52,500
Research & Evaluation		25,000
Total:	$1,402,938	$ 87,500
Equivalent Annual Cost	$ 400,200	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 40,000	$220,000
Equipment & Facilities	2,000,000	160,000
Planning	25,000	
Administration & Training		60,000
Total:	$2,065,000	$440,000
Equivalent Annual Cost	$ 706,400	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 100,000	$308,000
Equipment	1,462,000	14,000
Administration & Planning	10,000	110,000
Related Materials		308,000
Research & Evaluation		150,000
Total:	$1,572,000	$890,000
Equivalent Annual Cost	$1,092,800	

TABLE 69

SINGLE CHANNEL RADIO

REGION

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 20,000
Equipment & Facilities	$ 300,000	
Administration Training & Planning	120,000	
Programs & Materials	1,377,000	420,000
Research & Evaluation		100,000
Total:	$ 1,797,000	$ 540,000

Equivalent Annual Cost $ 912,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 400,000	$2,200,000
Equipment & Facilities	20,200,000	1,600,000
Planning	250,000	
Administration & Training		600,000
Total:	$20,850,000	$4,400,000

Equivalent Annual Cost $ 7,090,000

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 1,000,000	$3,080,000
Equipment	14,620,000	140,000
Administration & Planning	100,000	1,100,000
Related Materials		3,080,000
Research & Evaluation		1,500,000
Total:	$15,720,000	$8,900,000

Equivalent Annual Cost $10,928,000

TABLE 70

FOUR-CHANNEL RADIO

LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		
Equipment & Facilities	$36,000	4,000
Administration Training & Planning	3,000	
Programs & Materials	129,500	12,000
Research & Evaluation		4,500
Total:	$168,500	20,500
Equivalent Annual Cost	$ 55,446	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 1,500	$18,000
Equipment & Facilities	11,500	5,000
Planning	4,800	
Administration & Training	1,500	4,000
Total:	$19,300	$27,000
Equivalent Annual Cost	$29,490	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$10,000	$ 4,400
Equipment	30,750	500
Administration & Planning	4,000	10,000
Related Materials		22,000
Research & Evaluation		5,500
Total:	$44,750	$42,400
Equivalent Annual Cost	$48,173	

TABLE 71

FOUR-CHANNEL RADIO

CITY

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$
Equipment & Facilities	$ 45,000	5,000
Administration Training & Planning	8,000	2,000
Programs & Materials	233,100	27,000
Research & Evaluation		8,000
Total:	$286,100	$ 42,000
Equivalent Annual Cost	$102,683	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 3,000	$ 30,000
Equipment & Facilities	65,000	6,000
Planning	5,000	
Administration & Training	2,000	6,000
Total:	$ 75,000	$ 42,000
Equivalent Annual Cost	$ 51,675	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 12,000	$ 45,600
Equipment	290,000	2,000
Administration & Planning	2,000	20,000
Related Materials		200,000
Research & Evaluation		15,000
Total:	$304,000	$282,600
Equivalent Annual Cost	$321,816	

TABLE 72

FOUR-CHANNEL RADIO

METROPOLITAN

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 10,000
Equipment & Facilities	$ 60,000	
Administration Training & Planning	10,000	22,000
Programs & Materials	2,237,625	40,000
Research & Evaluation		10,000
Total:	$2,307,625	$ 82,000
Equivalent Annual Cost	$ 607,900	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 8,000	$ 50,000
Equipment & Facilities	150,000	25,000
Planning	9,000	3,000
Administration & Training	3,000	45,000
Total:	$ 170,000	$123,000
Equivalent Annual Cost	$ 144,900	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 18,000	$182,400
Equipment	1,200,000	12,000
Administration & Planning	3,000	
Related Materials		360,000
Research & Evaluation		100,000
Total:	$1,221,000	$654,400
Equivalent Annual Cost	$ 811,900	

TABLE 73

FOUR-CHANNEL RADIO

STATE

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 20,000
Equipment & Facilities	$ 150,000	
Administration Training & Planning	12,000	
Programs & Materials	2,581,875	90,000
Research & Evaluation		50,000
Total:	$2,743,875	$ 160,000
Equivalent Annual Cost	$ 777,300	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 12,000	$ 440,000
Equipment & Facilities	2,100,000	260,000
Planning	40,000	
Administration & Training		70,000
Total:	$2,152,000	$ 770,000
Equivalent Annual Cost	$1,047,600	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 100,000	$ 308,000
Equipment	2,200,000	22,000
Administration & Planning	10,000	150,000
Related Materials		616,000
Research & Evaluation		300,000
Total:	$2,310,000	$1,396,000
Equivalent Annual Cost	$1,694,000	

TABLE 74

FOUR-CHANNEL RADIO

REGION

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 35,000
Equipment & Facilities	$ 600,000	
Administration Training & Planning	220,000	
Programs & Materials	2,754,000	420,000
Research & Evaluation		100,000
Total:	$ 3,574,000	$ 555,000
Equivalent Annual Cost	$ 1,297,000	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 700,000	$ 4,700,000
Equipment & Facilities	21,000,000	2,000,000
Planning	400,000	700,000
Administration & Training		
Total:	$22,100,000	$ 7,400,000
Equivalent Annual Cost	$10,250,900	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 1,000,000	$ 3,080,000
Equipment	22,000,000	220,000
Administration & Planning	100,000	1,500,000
Related Materials		6,160,000
Research & Evaluation		600,000
Total:	$23,100,000	$11,560,000
Equivalent Annual Cost	$14,539,900	

TABLE 75

EDUCASTING

METROPOLITAN

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 10,000
Equipment & Facilities	$ 60,000	
Administration Training & Planning	10,000	22,000
Programs & Materials	2,237,625	40,000
Research & Evaluation		10,000
Total:	$2,307,625	$ 82,000

Equivalent Annual Cost $607,900

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 4,000	$ 35,000
Equipment & Facilities	145,000	32,500
Planning	4,000	2,000
Administration & Training	3,000	31,000
Total:	$156,000	$ 100,500

Equivalent Annual Cost $120,600

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 18,000	$ 182,400
Equipment		656,640
Administration & Planning	3,000	
Related Materials		360,000
Research & Evaluation		100,000
Total:	$ 21,000	$1,299,040

Equivalent Annual Cost $1,301,700

TABLE 76

EDUCASTING

STATE

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 20,000
Equipment & Facilities	$ 150,000	
Administration Training & Planning	12,000	
Programs & Materials	2,581,875	90,000
Research & Evaluation		50,000
Total:	$2,743,875	$ 160,000
Equivalent Annual Cost	$ 777,300	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 40,000	$ 220,000
Equipment & Facilities	2,075,000	160,000
Planning	30,000	
Administration & Training		60,000
Total:	$2,145,000	$ 440,000
Equivalent Annual Cost	716,700	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 100,000	$ 308,000
Equipment		1,108,800
Administration & Planning	10,000	150,000
Related Materials		616,000
Research & Evaluation		300,000
Total:	$ 110,000	$2,482,800
Equivalent Annual Cost	$2,497,000	

TABLE 77

EDUCASTING

REGION

PRODUCTION	CAPITAL	OPERATING
Personnel & Supplies		$ 35,000
Equipment & Facilities	$ 600,000	
Administration Training & Planning	220,000	
Programs & Materials	2,754,000	420,000
Research & Evaluation		100,000
Total:	$ 3,574,000	$ 555,000
Equivalent Annual Cost	$ 1,297,000	

DISTRIBUTION	CAPITAL	OPERATING
Personnel & Supplies	$ 400,000	2,200,000
Equipment & Facilities	20,000,000	1,600,000
Planning	750,000	
Administration & Training		600,000
Total:	$21,150,000	$ 4,400,000
Equivalent Annual Cost	$ 7,128,000	

RECEPTION	CAPITAL	OPERATING
Teacher Training	$ 1,000,000	$ 3,080,000
Equipment		11,088,000
Administration & Planning	100,000	1,500,000
Related Materials		6,160,000
Research & Evaluation		3,000,000
Total:	$ 1,100,000	$24,828,000
Equivalent Annual Cost	$24,970,000	

TABLE 78

COSTS PER PUPIL -- SINGLE CHANNEL RADIO SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$ 5.28	$ .85	$ .77	$ 1.20	$ 2.27	$ 1.56	
Equivalent Annual Cost	$ 1.97		$ 1.30		$ 1.85		$ 5.12
CITY	$ .94	$ .17	$ .43	$ .17	$ 1.44	$ 1.28	
Equivalent Annual Cost	$ .37		$ .23		$ 1.47		$ 2.07
METRO	$ 1.93	$ .10	$ .26	$ .14	$ 1.54	$ .86	
Equivalent Annual Cost	$ .54		$ .17		$ 1.06		$ 1.77
STATE	$ 1.40	$ .09	$ 2.06	$ .44	$ 1.57	$ .89	
Equivalent Annual Cost	$ .40		$ .71		$ 1.09		$ 2.20
REGION	$ .18	$ .05	$ 2.08	$ .44	$ 1.57	$ .89	
Equivalent Annual Cost	$ .09		$ .71		$ 1.09		$ 1.89

TABLE 79

COSTS PER PUPIL -- FOUR-CHANNEL RADIO SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL	$11.23	$ 1.37	$ 1.29	$ 1.80	$ 2.98	$ 2.83	
Equivalent Annual Cost	$ 3.70		$ 1.97		$ 3.21		$ 8.88
CITY	$ 1.91	$ .28	$ .50	$ .28	$ 2.03	$ 1.88	
Equivalent Annual Cost	$ .68		$ .34		$ 2.15		$ 3.17
METRO	$ 3.85	$ .14	$ .28	$ .20	$ 2.04	$ 1.09	
Equivalent Annual Cost	$ 1.01		$ .24		$ 1.35		$ 2.60
STATE	$ 2.74	$ .16	$ 2.15	$ .77	$ 2.31	$ 1.40	
Equivalent Annual Cost	$ .78		$ 1.05		$ 1.69		$ 3.52
REGION	$ .36	$ .06	$ 2.21	$ .74	$ 2.31	$ 1.16	
Equivalent Annual Cost	$ .13		$ 1.03		$ 1.45		$ 2.61

TABLE 80

COSTS PER PUPIL -- EDUCASTING SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
LOCAL							
Equivalent Annual Cost							
CITY							
Equivalent Annual Cost							
METRO	$ 3.85	$ .14	$ .26	$ .17	$ .04	$ 2.16	
Equivalent Annual Cost	$ 1.01		$ .20		$ 2.17		$ 3.38
STATE	$ 2.74	$ .16	$ 2.14	$ .44	$ .11	$ 2.48	
Equivalent Annual Cost	$ .78		$ .72		$ 2.50		$ 4.00
REGION	$ .36	$ .06	$ 2.12	$ .44	$ .11	$ 2.48	
Equivalent Annual Cost	$ .13		$ .71		$ 2.50		$ 3.34

SECTION E

LEARNING AND LANGUAGE LABORATORIES

LEARNING & LANGUAGE LABORATORIES

Introduction

For the purposes of this study, learning laboratories and language laboratories are defined in the following manner.

A learning laboratory is an audiopassive system that can be coupled with visual presentation methods in order to reinforce the instruction being transmitted orally. The system described in this section, however, will be costed without visual equipment and materials because these areas are covered in the audiovisual media system discussion.

A language laboratory is used to train the student in oral linguistic development by providing authentic and consistent models of speech for imitation and drill. Thus, the language laboratory must be an audioactive or an audioactive-compare system. For the purposes of this report, however, an audioactive-compare laboratory is a language laboratory. An audioactive laboratory was costed, and it was found to approximate the cost of a comparable audiopassive (learning) laboratory. The results are shown in Table 91.

To a great extent, audioactive-compare laboratories depend on the student's ability to compare his pronunciation with the model. Some laboratories allow the teacher to listen, but the student must judge his own progress for the majority of the time. This may be too much to expect of younger students; therefore, it is assumed that audioactive-compare laboratories will be installed only in high schools and colleges.

Audiopassive laboratories may be used on any educational level. For this study, however, only those installed in elementary schools will be considered. It is assumed that 90% of all learning material used in the laboratory will be developed in the school or school system, and only 10% will be purchased from commercial sources. It is further assumed that materials purchased for an audiopassive laboratory will be of a general nature and will not have to relate to a particular course at any specific time. The costs of both types of materials are considered to be the same.

The discussions of learning and language laboratories both deviate from the format of previous media descriptions. The high distribution costs on the metropolitan, state, and regional levels, when compared to the costs of purchasing and distributing the materials within smaller geographical areas, dictated the omission of these areas in the discussion. Five different 30-position laboratories and a 90-position audioactive-compare laboratory are costed. They should not be compared with other media systems.

NOTE: All equipment and material costs quoted in this section are based on prices quoted in request forms submitted by colleges and state governments for matching funds from the Federal government under authority of Title VI of the Higher Education Act of 1965. Quantities were determined so as to make this system comparable to the other systems in this study.

Equipment Descriptions

The audiopassive system provides information to a student via earphones or a loudspeaker. The student takes notes, uses a workbook, or controls some apparatus on his desk such as a slide projector. Program source material is controlled by a laboratory attendant who distributes one or many programs to the students simultaneously. The students are directed to listen to the appropriate program. Distribution is accomplished either by running wires from source to receiver or by electromagnetically transmitting the signal over a small area and using special receivers to pick up the signal without wires. The latter system is more effective when students must move around a great deal or when running wires is prohibited.

The hardware for the audioactive system is similar to that used in the audiopassive system with the addition of a microphone and an amplifier. The program material played on this system is designed to allow time on the recording for the student to reply to the programmed material. The student's reply is amplified and immediately fed back into his earphones. He is then able to compare his amplified voice to the recorded voice.

The audioactive-compare system hardware is basically a two-track tape recorder modified in order to make it easier for the student to operate. The program material is designed to allow the student to record his voice on the second track at appropriate times during the program. The student is then expected to compare his voice to the recorded voice and to repeat the exercise, making any necessary corrections, until the comparison meets with his satisfaction.

Production

The audiopassive, audioactive, and audioactive-compare systems use the same equipment to produce materials. For the production of language tapes, a school requires a recording studio, a good quality tape recorder, a multi-tape duplicator, and perhaps a technician's console to add sound effects and perform other editing functions. The only other requirement is blank tape. A wide selection of language tapes is commercially available. Some companies provide an entire multi-media course including texts, motion picture films, and language laboratory tapes. Most tapes for nonlanguage courses must be recorded in-house.

Disk recordings can be used on all three systems. There is an experimental device presently being used in four language research laboratories which has the program material and subaudible cueing recorded on a disk. It uses a short length of magnetic tape to record the cued phrase off of the record. This tape, in turn, is used to repeat the phrase and to record and repeat the student's voice.[1]

Production equipment can vary from a small tape recorder used in a classroom after hours (approximate cost $185) to a soundproof recording studio connected electrically to a control room where a technician handling the technical aspects of the recording awaits the teacher's signal to begin. A school that actively uses its learning or language laboratory might have two recording studios for use at the end of the school day when more than one teacher might desire to record a lesson. One technician can handle two simultaneous recordings without the necessity of duplicating recording equipment. Two studios per school will be priced. A recording studio measures around 50 square feet in size. At $18.50 per square foot, a recording facility would cost $925. The equipment for the studio including a chair, a desk, a wind-proof microphone, a push button for signalling the recording equipment operator, and a ready light signalling that the operator is ready would cost approximately $300, $100 for the furniture and $200 for a high quality microphone.

The control room measuring 100 square feet at $18.50 per square foot would cost $1850. The equipment required is: one master recorder - $2000; one tape duplicator which can also be a second master recorder when needed - $4000; an audio control console for editing, splicing, and adding special effects - from $1400 to $2650; a tape splicer - from $10 to $70; and a portable master recorder - $1800. This gives a high range total for equipment of $10,520. As mentioned earlier, a $185 tape recorder might suffice and, for making duplicates of the master, a few more models of the same recorder might be purchased. However, a noticeable difference in the quality of the finished tape will be found, and, for the purposes of this study, the recording quality of a $185 recorder would be unacceptable. More expensive control room equipment than that cited is available, and a great many systems can be purchased at prices between these extremes. Each specific situation would have to be examined individually to determine the best trade-off among price, recording quality, equipment reliability, teacher operated or technician operated control, sound effects and background music, portability requirements, duplicate tapes, etc.

In addition, the equipment must be maintained. If a full time operator technician is to be employed, he would also be expected to maintain the reception and recording equipment. For this purpose, a set of tools ($150), an oscilloscope ($200), an audio signal generator ($350), and a vacuum tube voltmeter ($100) are required. This is neither the high nor the low range in the cost of test equipment. The actual choice of tools and test equipment should be left to the laboratory technician.

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[1] Dean Charles G. Hurst, Jr., Howard University, Washington, D. C., researcher.

Another capital cost is the program material which is available for use with the system as soon as the equipment is installed. Assuming that either audioactive or audioactive-compare equipment is installed in a high school and that every language class is scheduled to use the laboratory one class period per week, approximately 225 hours of material are required during the first year. This figure is based on the following courses with one or more sections using the laboratory: French I-IV, Spanish I-IV, German I-IV, and one other language section such as English as a second language, Russian I or Italian I. The number of hours will increase somewhat if Latin classes are using the laboratory. Also, this figure is based on utilizing 34 of the 36 weeks in the school year. It is assumed that very little software can be produced in-house for use during the first year. The purchase price for these materials based on $7.50 per 1/2 hour lesson amounts to $3375.

Present copyright law prohibits the duplication of purchased tapes without the expressed approval of the copyright holder. This law is presently under review. Until it is changed, cost savings can be realized by negotiating for the right to duplicate purchased tapes at the time of the purchase. Duplication is a time-consuming process because tape must be run in order to be duplicated, unlike disks which are stamped. Running speed can be increased so that duplication time is from 1/2 to 1/4 playing time. A technician should duplicate in his spare time. Raw tape can be purchased in bulk at $1.00 to reduce costs or it can be purchased in standard size lengths on plastic reels at $2.50 per reel.

Operating a production center would require an operating/maintenance technician. The nature of this equipment is such that training costs would be very low for any experienced technician. The cost of a technician's salary can be split between operating and maintaining the production center and operating and maintaining the laboratory itself. The technician's salary would be based on many variables, but $7,000 is a reasonable figure.

Replacement parts to maintain the production equipment will rise every year that the equipment is in service. A good budget figure would be $100. With the widespread acceptance of transistorized (solid state) circuitry yielding low replacement costs and high reliability, maintenance costs are at a new low. This trend should continue with the increased reliability of equipment being built with integrated circuits.

Because the cost of commercially produced program material is low, the actual cost of producing a program in-house will be equal to or higher than the purchase price of the same program. An in-house capability is needed to produce nonlanguage material which is not readily available commercially. The selection of language tapes is large. In fact, there are whole multi-media language course materials available commercially. The school using a laboratory for languages only is advised to purchase only the minimal amount of production equipment. A good recorder is required, however, since high-fidelity reproduction of the spoken word is required in order to transmit all of the fine points of the spoken language. For the purposes of this study, a $2000 recorder is priced.

Distribution

The distribution equipment is an operator's console which has recorded players, magnetic tape players, and switches to distribute the appropriate lesson to each student. The actual transfer of the signals is accomplished by means of wires or a single or multi-channel transmitter and an antenna shaped to contain the signals within the desired area.

In an audiopassive learning laboratory, the laboratory operator, who could be either the technician or the instructor, would operate from a console capable of playing a combination of records and/or magnetic tapes. The operator could put on a number of programs and distribute each program through manual switching to the appropriate student.

The operator's console is the distribution equipment for audiopassive and audioactive systems as well as for an audioactive-compare system. Operators' consoles, containing program sources and distribution switching, cost approximately $1500. A single-channel system does not require any switching on a console and could operate with the $185 tape recorder, or a record changer and a preamplifier which require the same investment. The wires leading from the console to the student station are part of the reception equipment. However, a wireless system does exist and its distribution costs are different from those of the wired-in systems. The wireless system requires a transmitter and a program source. The transmitter costs $250 and the manufacturer's tape recorder program source costs $240 for one channel. Thus, the cost is over $500 for one channel including loop antenna for transmission. Two to four channels (more than one and up to four channels) require a $580 transmitter and two to four $240 program sources for a distribution cost of $1580 including a loop antenna around the periphery of the room. An audioactive system has the identical distribution components as an audiopassive system in both the wired-in and wireless versions.

The cost of operating the distribution system is low whether it is done by the instructor or the operating technician. The console is not complicated and there is little training required to operate it. Equipment maintenance and replacement of spare parts should be low in annual cost. The switching network is replaced with a transmitter in the wireless version, which is inherently less reliable than mechanical switches. As a result, maintenance cost would be a little higher. It should be noted that in the wired-in version, switching is a distribution function controlled by the system operator. In the wireless version, switching is a reception function and the operator must inform each student to which channel to tune.

Distribution costs for an audioactive-compare system can be the same as for the other systems. That is to say, the operator's console can be one source of the student's lesson. This distribution method, however, keeps him in locked step with the other students listening to the same lesson which is contrary to the concept of individualized instruction provided by the system. Consequently, it is assumed that an audioactive-compare laboratory will distribute a reel of tape to each student which has been duplicated from a master tape. This duplicate tape is retained by him until he has completed the lesson.

Duplicate tapes take 7 1/2 minutes to prepare from a 30 minute master. One operator can make three duplicates simultaneously. Raw tape costs are assumed to be $2.00 per reel for small operations and $1.00 per reel for large operations. An operator's salary is assumed to be $3.00 per hour. An operator can make six sets of duplicates per hour or 18 tapes. This results in a duplicate tape cost of $2.17 not including master tape and duplicating recorder amortizations. These are considered separately.

Reception

Audiopassive Systems

Reception equipment for an audiopassive system is basically a pair of headphones for each student. The market abounds with signal splitting devices called jack boxes, the majority of which accommodate eight headset plugs. Such a device can plug into the $185 tape recorder and serve eight students, or it can serve seven students and an additional piggy back jack box which, in turn, can serve eight more students. The practical limit of this piggy back scheme is four jack boxes plus the one plugged into the tape player to serve a total of 32 students. This reception scheme costs $50 for the five jack boxes and $800 for the 32 headsets at $25 per set. This results in reception costs of $850, and the system is highly mobile. Again, the equipment costs cited are typical, not minimum.

At the other end of the cost spectrum is a wired-in learning laboratory with individual student carrels and a jack box built into each carrel. The student plugs his earphones into his own jack box. Thirty carrels with wings (not wholly necessary in an audiopassive system) would range from $42 to about $95 per student, depending on the brand used. This is a cost range of $1260 to $2850 for 30 carrels. Student stations without wings have been noted for about $21 per station. In totalling reception costs, the figure of $75 for carrels with wings and chairs will be used for all three systems. Built-in, listen-only jack boxes ($33 per box, $1000 for 30 boxes) and headsets ($25 per headset, $750 for 30) is the equipment complement for reception. Total reception equipment cost is approximately $4,000.

Wiring-in a system can be done in three ways. The first method is to plan and build a school with a laboratory. This would result in concealed conduit, and would be least expensive. An expected cost of $300 for this wiring is reasonable though this may vary in different areas. Secondly, a laboratory can be wired in an existing building in either of two ways. The most common method is to lay a raceway on top of the existing floor and to run the wiring through it. Raceways are tapered to minimize the tripping hazard and the dirt-catching nuisance. Laying and wiring through raceways might cost about $400. The other method is to wire through a false ceiling. One manufacturer has a system in which the headsets are concealed in a false ceiling and, at the touch of a button at the operator's console, the headsets are lowered to the students' positions. Wiring this system costs about $700.

A wireless system may be purchased that has either special headsets with built-in tuned receivers or conventional headsets plugged into fixed receivers mounted in the carrels. Thirty receiver-integrated headsets cost $2,310 and receive one channel. Fixed receivers and conventional headsets cost $2,100 for 30, and the student is able to select from four channels. If student mobility is desired, the receiver-integrated headset is indicated.

No product line has been established, but it is conceivable and presently practical to have one or more channels sent through specially-constructed carpeting having separate, electrically conductive layers built beneath the nap of the rug. Special detector pins inserted into the carpeting would be able to detect signals implanted in the conductive layers at the operator's console. Since a pin inserted anywhere in the carpet would intersect the conductive layers, student mobility would be possible as long as the student remained still to listen to the lesson. In this case, wiring would be as expedient and as inexpensive as laying a carpet.

Facility cost for a learning laboratory is no more than for a classroom, excluding the extra wiring costs already accounted for. Thus, a laboratory encompassing an area of 1,000 square feet would cost $18,500.

Operating costs for the reception function are extremely small for the wired-in system and moderate for a system using individual receivers. As an example, manufacturers' service contracts for wireless systems cost around $175 per year.

Learning laboratories are traditionally administered by the school audiovisual director, and,therefore, the cost is difficult to assess. Assuming the presence of a full-time audiovisual director, no cost is allocated for the administration of a single laboratory.

Audioactive Systems

Audioactive and audiopassive systems do not differ in their equipment and costs in the production and distribution areas. Equipment differences and cost variances occur only in reception.

Audioactive reception uses the same carrels as the audiopassive system; the figure of $2,250 continues to be valid. Student jack boxes with built-in preamplifiers and combination headsets with microphones amount to $70 per station, a total of $2,100 for 30. Total reception equipment costs are $4,360, or $360 more for an audioactive system than for an audiopassive system. Thus, the active capability can be furnished for $12 more per position. No cost

TABLE 81

PRODUCTION COSTS - ALL AUTONOMOUS SYSTEMS

ITEM	AMOUNT	COST
Capital		
Master tape recorder	1	$ 2,000
Tape duplicator and second master recorder	1	4,000
Microphones	2	400
Portable recorder	1	1,800
Audio control console	1	2,650
Tape splicer	1	50
Test equipment	-	800
Wiring recording studios	-	50
Recording studio - 50 sq. ft.	2	1,850
Control room - 100 sq. ft.	1	1,850
*Initial software 100 hours	-	500
Tape storage cabinet	-	150
TOTAL		$16,100
Annual Operating		
*Operating maintenance personnel	-	$ 3,500
Replacement spare parts	-	100
*Program update	-	50
Raw tape	20	40
Related materials	-	100
TOTAL		$ 3,790

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 82

DISTRIBUTION COSTS - AUDIOPASSIVE AND AUDIOACTIVE SYSTEM - WIRED IN

ITEM	AMOUNT	COST
Capital		
Instructor's distribution console	1	$ 1,500
Test equipment	-	300
TOTAL		$ 1,800
Operating		
Maintenance personnel	-	$ 3,000
Replacement spare parts		50
TOTAL		$ 3,050

TABLE 83

RECEPTION COSTS - AUDIOPASSIVE SYSTEM WIRED IN

ITEM	AMOUNT	COST
Capital		
Carrels and chairs	30	$ 2,250
Headphones	30	750
Student jack boxes	30	1,000
Wiring	-	300
Facility - 1,000 sq. ft.	-	18,500
TOTAL		$22,800
Operating		
Replacement spare parts		20
Maintenance personnel		500
TOTAL		$ 520

differences arise in wiring the systems, but maintenance costs will increase somewhat because 30 amplifiers have been added to the system.

Reception costs rise a little more steeply in the wireless system. Single channel, active headsets with built-in receivers cost $20 more per headset for a total of $2,910. The fixed receiver with active capability, including headset and microphone costs $115 per student for a four-channel system. This is an additional $44 over audiopassive devices, and the total extra cost is about $1,350. Maintenance costs are the same for wireless equipment for both systems.

Audioactive-Compare System

Reception costs are the same as those for an audioactive laboratory with the addition of a $185 tape recorder for every student. However, there can be some savings where students are studying individually. The operator's console can be removed ($1,500) and the wiring cost and active jacks can be eliminated ($300 + $600). In other words, an audioactive-compare laboratory consists of chairs and carrels ($2,250) and tape recorders with active headsets ($185 + $35) x 33 = $6,930. (All audioactive-compare systems are costed on the basis of 10% more recorders than student stations.) Thus, the reception equipment for an audioactive-compare laboratory costs $9,180. Operating costs differ from the other systems because of the number of duplicate tapes that must be produced to satisfy student demands and the increase in maintenance costs due to the additional 30 recorders. Two or three spare recorders might be needed if reliability is found to be low and repair time high.

The following Tables 84 through 90 list the assumed costs for individual, single school wired-in and wireless systems. Table 91 summarizes the results of these tables.

Applications of Audiopassive and Audioactive-Compare Systems

The following applications of wired-in audiopassive and audioactive-compare laboratories have been studied.

- Elementary school - an audiopassive laboratory as previously described.
- High school - an audioactive-compare language laboratory with 30 positions.
- College - an audioactive-compare language laboratory with 90 positions.
- Local level - 14 audiopassive learning laboratories and four audioactive-compare language laboratories, each with 30 positions.
- City - 136 audiopassive and 46 audioactive-compare laboratories, each with 30 positions.

TABLE 84

LEARNING LABORATORY - AUDIOPASSIVE & AUDIOACTIVE SYSTEM

DISTRIBUTION - WIRELESS, SINGLE CHANNEL

ITEM	AMOUNT	COST
	Capital	
Instructor's transmitter	1	$ 245
Instructor's headset (Active)	1	97
Lesson source (Tape Player)	1	240
Loop antenna	1	40
TOTAL		$ 622
	Annual Operating	
Maintenance personnel		$3,000
Replacement spare parts		100
TOTAL		$3,100

TABLE 85

LEARNING LABORATORY - AUDIOPASSIVE & AUDIOACTIVE SYSTEM

DISTRIBUTION - WIRELESS, FOUR CHANNEL

ITEM	AMOUNT	COST
	Capital	
Instructor's transmitter	1	$ 580
Instructor's headset (Active)	1	109
Lesson sources	4	960
Loop antenna	1	40
TOTAL		$1,689
	Annual Operating	
Maintenance Personnel		$3,000
Replacement spare parts		125
TOTAL		$3,125

TABLE 86

LEARNING LABORATORY - AUDIOPASSIVE SYSTEM

RECEPTION - WIRELESS, 1-4 CHANNELS

ITEM	AMOUNT	COST
	Capital	
Carrels and chairs	30	$ 2,250
Facility - 1,000 sq. ft.	-	18,500
Students' headsets @ $77	30	2,130
TOTAL		$22,880
	Annual Operating	
Maintenance personnel		$ 500
Replacement spare parts		100
TOTAL		$ 600

TABLE 87

LEARNING LABORATORY - AUDIOACTIVE SYSTEM

RECEPTION - WIRELESS, SINGLE CHANNEL

ITEM	AMOUNT	COST
	Capital	
Carrels and chairs	30	$ 2,250
Facility - 1,000 sq. ft.	-	18,500
Students' headsets @ $97	30	2,910
TOTAL		$23,660
	Annual Operating	
Maintenance personnel		$ 500
Replacement spare parts		200
TOTAL		$ 700

TABLE 88

LEARNING LABORATORY - AUDIOACTIVE SYSTEM

RECEPTION - WIRELESS, 2-4 CHANNELS

ITEM	AMOUNT	COST
	Capital	
Carrels and chairs	30	$ 2,250
Facility - 1,000 sq. ft.	-	18,500
Students' headsets @ $115	30	3,450
TOTAL		$24,200
	Annual Operating	
Maintenance personnel		$ 500
Replacement spare parts		225
TOTAL		$ 725

TABLE 89

LANGUAGE LABORATORY AUDIOACTIVE-COMPARE

DISTRIBUTION

ITEM	AMOUNT	COST
Inital raw tape @ $2.50/roll	100	$ 250
Tape storage cabinets		200
TOTAL		$ 450
Annual Operating		
Operating personnel	-	$1,000
Consumable supplies (raw tape)	-	50
TOTAL		$1,050

TABLE 90

LANGUAGE LABORATORY AUDIOACTIVE-COMPARE

RECEPTION

ITEM	AMOUNT	COST
Student recorders @ $210	33	$ 6,930
Carrels and chairs	30	2,250
*Facility - 1,000 sq. ft.	-	18,500
Test equipment	-	500
TOTAL		$28,180
Annual Operating		
*Operating & maintenance personnel	-	$ 3,500
Spare parts		500
TOTAL		$ 4,000

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 91

SUMMARY COSTS FOR VARIOUS LEARNING LABORATORY CONFIGURATIONS- 30 STUDENT POSITIONS

	PRODUCTION		DISTRIBUTION		RECEPTION	
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING
Audiopassive Wired-in	16,100	3790	1800	3050	22,800	520
Audiopassive Wireless	16,100	3790	1 Channel 622 4 Channel 1689	3100 3125	1 Channel 22,880 4 Channel 22,880	600
Audioactive Wired-in	16,100	3790	1800	3050	23,160	1050
Audioactive Wireless	16,100	3790	1 Channel 622 4 Channel 1689	3100 3125	1 Channel 23,660 4 Channel 24,200	700 725
Audioactive Compare	16,100	3790	450	1050	28,180	4000

Elementary School

The learning laboratory in the elementary school is identical to the audiopassive system described earlier.

High School

The single high school cited uses the production equipment listed in Table 81 . However, the tape duplication costs and $200 of the cost of the tape storage cabinets are placed in the distribution category. Sufficient numbers of the master tapes must be copied for distribution to the individual students. The number of copies distributed changes with the availability of a tape duplicator. When a duplicator is available in a school, the total amount of tape in stock is equal to about two rolls of tape per student. This permits sufficient time to collect old tapes, furnish new tapes, and duplicate tapes for future use. Where a duplicator is not available locally, a full year's stock must be stored at each school. It is assumed that this would amount to 12,000 tapes valued at $1 each. At first glance, this appears to be more expensive than purchasing master tapes and a duplicator and duplicating as the need arises. A man (or student) must operate a duplicator, and this can be expensive because duplicating is a relatively slow operation. A duplicator is most efficiently used in an operation that has full-time technicians who duplicate tapes in their spare time.

Reception costs are high because every student is given his own $210 recorder on which to practice and drill. Even with resident technicians, three spare recorders are purchased to insure availability.

College

The language laboratory described for a college was designed with the following parameters. The college has 7,000 full-time students, 5,000 of whom are working for a degree requiring 16 language credit hours. The foreign language department offers 26 semester-long, 4 credit-hour courses requiring the student to use the language laboratory. It is assumed that the college has two technicians plus student labor to help operate and maintain the production, distribution (including duplication), and reception areas. The laboratory is located in an area, such as the library, where it may be used 16 hours per day, 7 days per week. If the laboratory is utilized 100% of the time, 45 student positions are needed, based on an average of two hours of drill per week. A more realistic utilization factor of 50% was chosen bringing the number of student positions to 90. One hundred machines were purchased to insure the availability of 90. Because of the timelessness of language tapes and because of the strength and longevity of modern polyester base materials from which tapes are made, a lifetime of 10 years was assumed for calculating amortization rates and program updating requirements.

The manpower complement consists of two technicians and sufficient student labor (32 hours per week) to insure one person on duty every hour that the system is in use. Tables 93, 94, and 95 list the assumed costs.

Local

The local level configuration consists of 14 elementary schools each having one audiopassive learning laboratory, and four secondary schools each having one audioactive-compare laboratory.

Production equipment for these laboratories consists of a central facility located in or near one of the high schools which has the full production capability listed in Table 96, a $1,000 master recorder in every elementary school and a $2,000 master recorder in every high school. The high schools also have a recording studio. The elementary school teachers, however, are expected to use the central facility or the learning laboratory in their own schools as a recording studio.

Because of the number of recorders located in the language laboratories in the secondary schools, one technician travels to every high school every day to service the equipment. In addition, he makes the rounds of the elementary schools on a schedule which insures that every school is visited at least once every three weeks. Emergency service is provided on a same day as requested basis as often as possible.

The cost of operating a truck, shown in Table 92, is distributed among the production, distribution and reception categories.

TABLE 92

TRUCK OPERATIONS

ITEM	COST
Amortization ($3,500 over 5 years at 5% interest)	$ 810
Maintenance	300
Gasoline ($.03 per mile over 15,000 miles)	450
Insurance	250
TOTAL	$1,810

TABLE 93

LANGUAGE LABORATORY AUDIOACTIVE-COMPARE — COLLEGE

PRODUCTION

ITEM	AMOUNT	COST
Capital		
Master tape recorder	1	$ 2,000
Tape duplicator and second master recorder	1	4,000
Microphones	2	400
Portable recorder	1	1,800
Audio control console	1	2,650
Tape splicer	1	50
Tape storage cabinet	-	400
Recording studio @ 64 sq. ft.	2	2,368
Control room - 100 sq. ft.	1	1,850
*Initial software 26 courses, 2 hrs/week, 17 weeks @ $15/hr.		13,260
*Initial teacher training		200
*Initial planning		1,000
Initial test equipment		250
TOTAL		$30,228
Annual Operating		
*Operating & maintenance personnel		$ 7,000
*Operating personnel training		100
Replacement spare parts		250
Consumable supplies		120
Related materials		50
Program update		1,717
TOTAL		$ 9,237

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 94

LANGUAGE LABORATORY AUDIOACTIVE-COMPARE — COLLEGE

DISTRIBUTION

ITEM	AMOUNT	COST
Capital		
Initial raw tape	-	$1,000
*Initial planning	-	500
TOTAL		$1,500
Annual Operating		
*Operating and maintenance personnel		$6,000
Consumable supplies (raw tape)		200
TOTAL		$6,200

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 95

LANGUAGE LABORATORY AUDIOACTIVE-COMPARE — COLLEGE

RECEPTION

ITEM	AMOUNT	COST
Capital		
Student recorders @ $210	100	$21,000
Carrels and chairs	90	6,750
*Facility, 2500 sq. ft.	-	46,250
Test equipment	-	200
TOTAL		$74,200
Annual Operating		
*Operating and maintenance personnel	-	$ 3,000
Spare parts		1,200
TOTAL		$ 4,200

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 96

LANGUAGE LABORATORIES - LOCAL

PRODUCTION COSTS

ITEM	AMOUNT	COST
Capital		
Tape recorders - elementary schools @ $1000	14	$14,000
Tape recorders - secondary schools @ $2000	4	8,000
*Centrally located production facility	-	15,600
*Recording facilities in 3 other high schools	3	2,775
*Truck	-	1,200
*Master tapes	-	4,000
Duplicates for elementary schools	14	7,000
Duplicates for high schools	4	1,800
*Initial teacher training @ 1 man-month per school	18	18,000
*Initial planning	-	3,000
TOTAL		$75,375
Annual Operating		
*Operating and maintenance personnel	-	$12,000
*Teacher training @ 1/50 man-year per school	18	4,320
*Administration	-	3,000
*Truck operation	-	210
Spare parts	-	540
Consumable supplies	-	900
Related materials	-	50
*Current programming	-	1,000
*Research, test and evaluation	-	1,000
TOTAL		$23,020

*These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 97

LANGUAGE LABORATORIES - LOCAL

DISTRIBUTION COSTS

ITEM	AMOUNT	COST
Capital		
Instructor's distribution console @ $1500	14	$21,000
Tape storage cabinets in secondary schools @ $200	4	800
*Test equipment and truck	-	1,600
*Initial operator training @ 1 man-week/el. school	14	3,500
*Initial planning	-	5,000
TOTAL		$31,900
Annual Operating		
*Maintenance personnel	-	$ 4,000
*Maintenance personnel training @ 1 man-month/year	-	580
*Administration	-	3,000
*Truck operation	-	800
Spare parts	-	700
Consumable supplies	-	200
Related materials	-	100
TOTAL		$ 9,380

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 98

LANGUAGE LABORATORIES - LOCAL

RECEPTION COSTS

ITEM	AMOUNT	COST
Passive laboratories with carrels @ $4000	14	$ 56,000
Active-compare laboratories @ 8860	4	35,440
* Facilities, 1000 sq. ft. @ $18.50/sq. ft.	18	333,000
* Wiring passive laboratories @ $300	14	4,200
* Initial planning	-	4,000
* Test equipment and truck	-	1,600
TOTAL		$434,240
Annual Operating		
* Maintenance personnel	-	$ 12,000
* Administration	-	2,500
* Truck operation	-	800
Spare parts @ $50/elem. & $200/sec.	-	1,500
Consumable supplies	-	100
Related materials	-	100
TOTAL		$ 17,000

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

City

The configuration of learning/language laboratories and production equipment is the same for the schools in a large city as in the local area previously described. Four large production areas replace the one in the local area.

Although not previously discussed, planning costs triple. Assuming that one man year of effort valued at $12,000 is required to plan the local level operation, an effort valued at $36,000 would be required to plan a large city's operation. It is assumed that 10 technicians and six trucks can keep all equipment operating. Truck operation is figured at $10,000 per year, a cost shared by all three phases: production, distribution, and reception.

Teacher training and technician training costs were considered. From one to one and one-half days of teacher time would be required initially for training in production techniques, or $182,000. This same amount of effort would be required to train new teachers, bringing the annual budget to a total of $43,680. Two hours training time per elementary school teacher to learn the operation of the operator's console is assumed. Total initial training cost is $34,000 and the yearly budget for the item is $1,750.

Cost Data Sheets

The following pages are cost data sheets which collect the costs in each category of production, distribution, and reception for each learning and language system in each area of application. These costs were obtained from the preceding descriptions.

The equivalent annual cost listed on the cost data sheets is a combination of the annual operating cost and amortization of the capital cost. Amortization periods of initial personnel, equipment, and facility costs are the same in this section as in the television sections, with the exception of educational programs. All language programs are amortized over 10 years, with the exception of elementary school programs which are amortized over three years, using the capital recovery factor of 0.3672.

Annual per pupil costs are presented in Table 107 following the cost data sheets.

TABLE 99

LANGUAGE LABORATORIES - CITY

PRODUCTION COSTS

ITEM	AMOUNT	COST
Capital		
Tape recorders - elementary schools @ $1000	136	$136,000
Tape recorders - secondary schools @ $2000	46	92,000
* Centrally located production facilities	4	62,400
* Recording facilities in high schools, 50 sq. ft.	46	42,400
* Truck	-	7,000
* Master tapes	-	4,000
Duplicates for elementary schools @ $500	136	68,000
Duplicates for high schools @ $450	46	20,700
* Initial teacher training @ 1 man-month per school	182	182,000
* Initial planning	-	12,000
TOTAL		$626,500
Annual Operating		
* Operating and maintenance personnel	-	$ 30,000
* Teacher training @ 1/50 man-year per school	182	43,680
* Administration	-	6,000
* Truck operation	-	2,000
Spare parts	-	5,000
Consumable supplies	-	200
Related materials	-	350
* Current programming	-	10,000
* Research, test & evaluation	-	2,000
TOTAL		$ 99,230

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 100

LANGUAGE LABORATORIES - CITY

DISTRIBUTION COSTS

ITEM	AMOUNT	COST
Capital		
Instructor's distribution console @ $1,500	136	$204,000
Tape storage cabinets in secondary schools @ $200	46	9,200
Test equipment and trucks	-	8,000
*Initial operator training @ 1 man-week/el. school	136	34,000
*Initial planning	-	12,000
TOTAL		$267,200
Annual Operating		
*Maintenance personnel	-	$ 10,000
*Maintenance personnel training @ 3 man-month/year	-	1,750
*Administration	-	6,000
*Truck operation	-	4,000
Spare parts	-	6,800
Consumable supplies	-	2,300
Related materials	-	600
TOTAL		$ 31,450

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 101

LANGUAGE LABORATORIES - CITY

RECEPTION COSTS

ITEM	AMOUNT	COST
Capital		
Passive laboratories with carrels @ $4000	136	$ 544,000
Active-compare laboratories @ 8860	46	408,000
*Facilities, 1000 sq. ft. @ $18.50/sq. ft.	182	3,370,000
*Wiring passive laboratories @ $300	136	40,800
*Initial planning	-	12,000
Test equipment and trucks	-	8,000
TOTAL		$4,382,800
Annual Operating		
*Maintenance personnel	-	$ 30,000
*Administration	-	5,000
*Truck operation	-	4,000
Spare parts @ $50/elem, and $200/sec.	-	16,000
Consumable supplies	-	700
Related materials	-	700
TOTAL		$ 56,400

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 102

LANGUAGE LABORATORY - ELEMENTARY SCHOOL

PRODUCTION	CAPITAL	OPERATING
Personnel		$3,500
Equipment	$11,900	100
Programs	500	50
Material		140
Facility	3,700	
Total:	$16,100	$3,790

Equivalent Annual Cost $5,770

DISTRIBUTION	CAPITAL	OPERATING
Personnel		$3,000
Equipment	$ 1,800	50
Programs		
Material		
Facility		
Total:	$ 1,800	$3,050

Equivalent Annual Cost $3,280

RECEPTION	CAPITAL	OPERATING
Personnel		$ 500
Equipment	$ 4,000	20
Programs		
Material		
Facility	18,800	
Total:	$22,800	$ 520

Equivalent Annual Cost $2,370

TABLE 103

LANGUAGE LABORATORY - SECONDARY SCHOOL

PRODUCTION	CAPITAL	OPERATING
Personnel		$3,500
Equipment	$11,900	100
Programs	500	50
Material		140
Facility	3,700	
Total:	$16,100	$3,790

Equivalent Annual Cost $5,650

DISTRIBUTION	CAPITAL	OPERATING
Personnel		$1,000
Equipment	$ 200	
Programs		
Material	250	50
Facility		
Total:	$ 450	$1,050

Equivalent Annual Cost $1,110

RECEPTION	CAPITAL	OPERATING
Personnel		$3,500
Equipment	$ 9,680	500
Programs		
Material		
Facility	18,500	
Total:	$28,180	$4,000

Equivalent Annual Cost $6,560

TABLE 104

LANGUAGE LABORATORY - COLLEGE

PRODUCTION	CAPITAL	OPERATING
Personnel	$ 1,200	$7,100
Equipment	11,550	250
Programs	13,260	1,717
Material		170
Facility	4,218	
Total:	$30,228	$9,237

Equivalent Annual Cost $16,050

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 500	$6,000
Equipment		
Programs		
Material	1,000	200
Facility		
Total:	$ 1,500	$6,200

Equivalent Annual Cost $ 6,390

RECEPTION	CAPITAL	OPERATING
Personnel		$3,000
Equipment	$27,950	1,200
Programs		
Material		
Facility	46,250	
Total:	$74,200	$4,200

Equivalent Annual Cost $11,100

TABLE 105

LANGUAGE/LEARNING LABORATORY - LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel	$21,000	$19,320
Equipment	35,100	750
Programs	4,000	2,000
Material	8,800	950
Facility	6,475	
Total:	$75,375	$23,020

Equivalent Annual Cost $32,500

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 8,500	$ 7,580
Equipment	23,400	1,500
Programs		
Material		300
Facility		
Total:	$31,900	$ 9,380

Equivalent Annual Cost $13,500

RECEPTION	CAPITAL	OPERATING
Personnel	$ 4,000	$14,500
Equipment	93,040	2,300
Programs		
Material		200
Facility	337,200	
Total:	$434,240	$17,000

Equivalent Annual Cost $53,470

TABLE 106

LANGUAGE/LEARNING LABORATORY - CITY

PRODUCTION	CAPITAL	OPERATING
Personnel	$ 194,000	$79,680
Equipment	282,400	7,000
Programs	4,000	12,000
Material	88,700	550
Facility	57,400	
Total:	$ 626,500	$99,230

Equivalent Annual Cost $177,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 46,000	$17,750
Equipment	221,200	10,800
Programs		
Material		2,900
Facility		
Total:	$ 267,200	$31,450

Equivalent Annual Cost $ 66,000

RECEPTION	CAPITAL	OPERATING
Personnel	$ 12,000	$35,000
Equipment	960,000	20,000
Programs		
Material		1,400
Facility	3,410,800	
Total	$4,382,800	$56,400

Equivalent Annual Cost $424,000

TABLE 107

COSTS PER PUPIL -- LANGUAGE/LEARNING LABORATORY SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
Elementary School	$40.25	$ 9.48	$ 4.50	$ 7.63	$57.00	$ 1.30	
Equivalent Annual Cost	$14.43		$ 8.20		$ 5.93		$28.56
Secondary School	$11.50	$ 2.71	$ 0.32	$ 0.75	$20.13	$ 2.86	
Equivalent Annual Cost	$ 4.04		$ 0.79		$ 4.69		$ 9.52
College	$ 4.32	$ 1.32	$ 0.21	$ 0.89	$10.60	$ 0.60	
Equivalent Annual Cost	$ 2.29		$ 0.91		$ 1.59		$ 4.79
Local	$ 5.03	$ 1.53	$ 2.13	$ 0.63	$28.95	$ 1.13	
Equivalent Annual Cost	$ 2.17		$ 0.90		$ 3.56		$ 6.63
City	$ 4.18	$ 0.66	$ 1.78	$ 0.21	$29.22	$ 0.38	
Equivalent Annual Cost	$ 1.18		$ 0.43		$ 2.83		$ 4.44

SECTION F

DIAL ACCESS

DIAL ACCESS

Introduction

Three different types of dial access systems have been costed. Two of the systems are used in an environment where the students study independently. These systems, audio-only and audio-video dial access systems, were envisioned for a university of 7,000 full-time students. The third system is suggested for application in school districts serving elementary and secondary schools. In this case, the students do not study independently, but the entire class receives the lesson over a loud speaker. Each and every classroom in the district can dial into the system.

The discussions of dial access and language laboratories both deviate from the format of previous media descriptions. The extremely high distribution costs at the state and regional levels dictated the omission of these areas in the discussion of elementary and secondary schools. However, since dial access systems presently are utilized successfully by universities at the state and regional levels, these areas are included in the discussion of dial access in higher education. The data should not be used to compare this system to other media systems at these two levels.

Audio System in a University Setting

The university audio facilities are the same for the audio-video system as for the audio-only system. The addition of video is considered a supplement to the audio programming, and it is costed as such. It is assumed that 10 percent of the total material presented on the university dial access system would require video supplements in the form of slides, motion picture film, or entire lessons recorded on video tape.

System Design

The design of the university dial access system was based on the following assumptions.

- The system will be in operation 16 hours per day, 7 days per week (112 hours).
- The average full-time student is taking 15 credit hours per semester.
- 500 courses are offered every semester.
- The instructional material of 1/3 of the courses can be put on the dial access system.

- An Average of 10 percent of that course material will be presented on the dial access system.

- The factor of maximum student loading deviation expected is two.

- The factor of maximum program loading deviation expected is two.

The last two assumptions are stated to indicate the degree of "bunching up" of students at student positions and programs on playback machines.

To calculate the number of student stations required, the maximum expected number of programs in the system and the maximum expected number of students using the system per hour must be determined.

First, the average number of programs per week is calculated. The number of course hours per week is 1/3 of 500 courses meeting three hours per week which equals 500 course hours per week. Ten percent of 500 course hours per week equals 50 program hours per week, on the average.

If the programs are left in the system for more than one week, e.g., two weeks, then the number of program hours per week must be multiplied by two. In this study, all programs are assumed to be left on the system for one week; therefore, no multiplier will be required.

The maximum deviation expected for program loading is twice the average load. In order to accommodate the maximum, the 50 program hours calculated earlier must be multiplied by two. Thus, 100 program sources are required if the programs on the players are nominally one hour in length.

The maximum expected student loading must now be calculated. The number of students in this university totals 7,000. All 7,000 will not be taking the 167 courses offering programs on the dial access system. However, these courses would attract a large percentage of the students. It is not possible to calculate the actual number of students in these courses; therefore, all calculations will be made on the worst case basis of 7,000 students. The difference between this number and the actual number of students taking the courses will be considered to be an allowance for future growth.

The required number of student stations is calculated as follows.

The maximum number of programs being presented in one week is 100. This is 20 percent of the available instruction for that week.

$$7{,}000 \text{ students} \times 15 \text{ hours/week} = 105{,}000 \ \frac{\text{student instruction hours}}{\text{week}}$$

$$20\% \times 105{,}000 \text{ hours} = 21{,}000 \ \frac{\text{student dial access instruction hours}}{\text{week}}$$

$$\frac{21{,}000 \text{ student hours/week}}{112 \text{ hours/week}} = 187.5$$ student stations to serve 7,000 students during one week in which the maximum amount of program material is presented.

Student loading variations are twice the average loading, and,therefore, 187.5 is multiplied by two which equals 350 student stations required.

In this example, the location of the student stations will all be in the same building, thus minimizing installation cost. However, in an actual school situation, the location of the carrels will have a definite bearing on the required number of student stations, since the student loading on the system will be strongly affected by the convenience of using the system.

Materials Production

Table 108 lists the capital and operating costs for production. It is assumed here that all initial software was produced by local talent; an instructor will utilize his own time and produce his own materials. However, it is doubtful whether a teacher will produce his own material on his own time and without remuneration. The bulk of the cost shown for the initial software is production's share of a year's salary for operating and maintenance personnel. If all materials are recorded prior to the installation of the equipment, the same figure would result except that it would be the sum of one recording technician's salary and faculty relief time.

NOTE: All equipment and material costs quoted in this section are based on prices quoted in request forms submitted by colleges and state governments for matching funds from the Federal government under authority of Title VI of the Higher Education Act of 1965. These costs are by no means the result of a statistical study; rather, they are representative of the price ranges of the equipment actually being specified in the request forms. Quantities were determined primarily with the intention of making this system comparable to the other systems in this study.

Distribution

Distribution costs are listed in Table 109 . The costs listed therein, with the exception of those items with asterisks, are fairly typical costs based on the manufacturers' quoted prices and costs collected in the field.

Unfortunately, the largest cost, which is for switching equipment, cannot be ascertained with certainty. Inquiries to switching equipment manufacturers were ignored or did not result in detailed enough information to allow the development of a table by which cost and design guidelines could have been determined. Switching equipment presently comes in a wide variety of designs, each of which performs the

TABLE 108

PRODUCTION COSTS

COLLEGE - AUDIO ONLY

ITEM	AMOUNT	COST
Capital		
Master recorders	10	$20,000
Rack mounting (recorder)	1	500
Duplicators	4	10,000
Rack mounting (duplicator)	4	1,500
Tape splicers	2	100
Portable recorder	1	2,000
Control consoles	2	4,000
*Recording studios	10	11,800
*Control room, 200 sq. ft.	1	3,700
*Initial software	-	21,500
*Initial teacher training	-	10,000
*Initial operator training	-	2,500
*Initial planning	-	4,000
Initial test equipment	-	600
TOTAL		$92,200
Annual Operating		
*Operating and maintenance personnel	-	$19,850
*Teacher training	-	1,000
*Operating personnel training	-	500
*Administration	-	6,000
Replacement spare parts	-	1,000
Consumable supplies	-	100
Related materials	-	100
*Current programming	-	1,000
*Program update	-	7,000
*Research, test & evaluation	-	1,000
TOTAL		$37,550

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 109

DISTRIBUTION COSTS

COLLEGE - AUDIO ONLY

ITEM	AMOUNT	COST
Capital		
1-track tape players	30	$ 12,000
4-track tape players	20	8,000
Rack mounting	-	1,500
Power supplies and amplifiers	-	5,000
Tape storage	-	800
Switching equipment	-	75,000
Installation	-	8,400
*Control room, 800 sq. ft.	-	14,800
*Initial operator training	-	2,500
*Initial planning	-	4,000
Initial test equipment	-	600
*Expansion capability - spare switching	-	4,000
TOTAL		$136,600
Annual Operating		
*Operating & maintenance personnel	-	$ 19,850
*Operating personnel training	-	500
*Administration	-	6,500
Replacement spare parts	-	1,000
Consumable supplies	-	100
Related materials	-	200
TOTAL		$ 28,150

* These costs are largely dependent upon the actual rate of charge in the individual setting, and the degree to which a school system might already be budgeting for these items.

function of calling up and connecting a program to the dialing receiver. Each switching design functions differently, and each has a maximum cost efficiency at a different sized load.

The costs of switching equipment which are listed in this section were derived as accurately as possible by interpolation from historical data. However, the historical data on switching equipment is sparse. In spite of the fact that cost data exist in varying degrees of depth for dial access systems in 13 schools and colleges, the components of these systems are not always priced.

Expansion costs are noted for extra switching capability. This is not always a specifiable commodity, however. Switching equipment is built in modules of a standard matrix size. The number of modules necessary to do the job are installed, and, most probably, the equipment installed is large enough to handle a few more carrels and/or program sources than are initially connected in the system. Further expansion would undoubtedly be greater than the handling capability of the existing switching equipment. Therefore, when considering a system expansion, the module sizes of the switching equipment should be kept in mind to minimize future costs.

The tape players listed are sufficient to provide 80 programs on 20 machines with scheduled start operation, 20 programs on 20 machines with either scheduled or automatic start, and 10 machines to play special request tapes which are not scheduled on the regular program. In the latter case, the student would call a special number using a telephone headset or handset to make a specific request of the operator. More elaborate schemes than this could be concocted. However, it would be necessary to have enough playback machines to have the entire 1,800 tape inventory available for automatic playback in order to implement them. A rough estimate of the additional expense of this undertaking is $ 2 1/4 million.

Reception

A list of the audio reception costs will be found in Table 110 . The costs of the equipment listed are typical and do not imply optimal costs or the results of cost-quality tradeoff considerations. Such considerations are not included.

The expansion capability shown indicates that conduit is laid beneath the surface of the floor at the time the building is constructed. Had this not been done, future expansion would be prohibitive because of the need to either dig up the present floor or lay a false floor to hide and protect the cables. If future expansion is anticipated, extra conduit should be installed initially as insurance against future exorbitant costs. No expansion cost is noted for the space under the conduit. It is assumed that the space will be used for other purposes until the need for expansion occurs.

Cost Reduction With Dial Access

When a new college or a rapidly expanding college or university investigates the use of a dial access system, the cost structure of the entire university should be studied.

TABLE 110

RECEPTION COSTS

COLLEGE - AUDIO ONLY

ITEM	AMOUNT	COST
Capital		
Student carrels & chairs	375	$ 28,125
Headphones	375	9,375
Dial sets	375	24,400
*Installation	-	1,600
*Reception area, 4,690 sq. ft.	-	86,600
*Initial operator training	-	2,000
*Initial planning	-	4,000
Initial test equipment	-	600
Expansion capability - conduit installed		600
TOTAL		$157,300
Annual Operating		
*Operating & maintenance personnel	-	$ 4,412
*Operating personnel training	-	200
*Administration	-	5,000
Replacement spare parts	-	500
Consumable supplies	-	50
Related materials	-	100
TOTAL		$ 10,262

* These costs are largely dependent upon the actual rate of charge in the individual setting, and the degree to which a school system might already be budgeting for these items.

The association of costs is highly intricate and every situation is different. For example, an institution that furnishes (or rents) a carrel to every full-time student and supplies 50% or more of the instruction available at the university on the dial access system, can economize on classroom space, and, in addition, allow the instructor much more time for direct interface with the student. If the dormitory complex on campus is large, the student stations can be collocated with the desks in the dormitory rooms. On the other hand, if a central facility houses all of the student stations, individual carrels can be assigned to each student. In this case, dormitories need not have study areas and the amount of study space in the library can be reduced. (118)

Even a scheme such as the one presented in this study frees instructors a few more hours per week, and this time can be devoted to students who may require additional attention. Potential classroom space savings can be realized with proper scheduling. This scheduling can be done easily on a computer. The student need only have one or two different class meetings per course per week. No attempt has been made to assess the possible cost savings in dollars which the dial access system described herein might generate. Probably this system will not pay for itself; however, the cost of providing the opportunity to study independently is not as high as appears at first glance.

Audio-Video System in a University Setting

The audio portion of this system is identical to the audio system discussed previously. Therefore, all discussion and tables will omit the audio aspects of this system. The table in this section must be added to Tables 108, 109 and 110 in order to obtain total system costs. Throughout this discussion all video is black and white; no provision for color has been made.

Table 111 lists the production costs associated with the video portion of the system. Table 112 lists the video distribution costs. The relatively large number of film chains indicates that the program material is composed largely of slides and motion picture film. It is assumed that photographic production material already exists and is administered by a general audiovisual department. Likewise, the television studio and control equipment could be eliminated if a television or television arts department exists on campus.

Table 113 lists the video reception costs. It is assumed that the technical personnel maintaining the production and distribution equipment will also maintain the reception equipment.

Video equipment is amortized over five years, and audio equipment is amortized for a 10 year period.

TABLE 111

PRODUCTION COSTS

COLLEGE - VIDEO CAPABILITY

ITEM	AMOUNT	COST
Capital		
T.V. cameras	5	$ 50,000
Control consoles	2	34,000
Video tape recorders (2 1/2 prod., 2 1/2 dist.)	5	38,500
Off-air receivers & processors	2	1,000
*T.V. studios (4500 sq. ft. @ $25)	2	112,500
*Installation	-	10,000
*Control room (2000 sq. ft. @ $20)	2	40,000
*Initial program material	-	20,000
*Initial teacher training	-	10,000
*Initial operator training	-	10,000
*Initial planning	-	12,000
Initial test equipment	-	1,500
TOTAL		$339,500
Annual Operating		
*Operating personnel	-	$102,000
*Maintenance personnel	-	14,000
*Teacher training	-	7,000
*Operating personnel training	-	4,000
Replacement spare parts	-	2,000
Consumable supplies	-	1,000
Related materials	-	200
*Current programming	-	1,000
*Program update	-	7,350
TOTAL		$138,550

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 112

DISTRIBUTION COSTS

COLLEGE - VIDEO CAPABILITY

ITEM	AMOUNT	COST
Capital		
T.V. distribution panel	1	$ 30,000
Film chain and multiplexers	8	128,000
Video tape recorder - reproducers (2 1/2 dist.)	5	38,500
*Control room (800 sq. ft.)	-	14,800
*Initial operator training	-	2,500
*Initial planning	-	4,000
Initial test equipment	-	1,300
TOTAL		$219,100
Annual Operating		
*Operating and maintenance personnel	-	$ 28,000
*Operating personnel training	-	750
Replacement spare parts	-	1,000
Consumable supplies	-	400
Related materials	-	200
TOTAL		$ 30,350

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 113

RECEPTION COSTS

COLLEGE - VIDEO CAPABILITY

ITEM	AMOUNT	COST
Capital		
Individual student monitors	375	$75,000
*Wiring and installation	-	13,110
*Initial planning	-	4,000
TOTAL		$92,110
Annual Operating		
*Operating personnel training	-	$ 200
Replacement spare parts	-	1,000
TOTAL		$ 1,200

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

Audio System In Elementary And Secondary Schools

The system described for use in elementary and secondary schools is composed of a dial set and a loudspeaker in every schoolroom for selecting and receiving desired programs. It is not patterned after any known existing system, nor is it recommended for implementation. Rather, this configuration was chosen in order to compare more closely dial access system costs with the costs of the other media systems under study.

This design allows the teacher to dial up a program for presentation to the entire class via the loudspeaker. If the teacher should want only selected students to receive the program while more personal instruction is given to the rest of the students, it would not be possible to do so in this system. However, equipment is presently being marketed that would permit the teacher to accomplish this. The reception cost per classroom would increase from $10 for the loudspeaker to $1,500 for headsets and wiring using this new system.

The costs assessed in this section are based on 20 classrooms in every elementary school and 46 classrooms in every secondary school. These numbers average out to 26 receivers per school. The substitution of a system consisting of a laboratory in every school which has 26 dial positions with student headsets can be accomplished by adding the following costs to the system.

$15 per headset (substituting for loudspeakers)
$75 per position, for carrels and chairs
$9,250 per school for facility costs (500 sq. ft. @ $18.50 per sq. ft.)

Production

The level of production capability was not kept constant as the system was applied at the various geographical levels. At the local level, every school was provided with a master recorder and a small recording room. Better recording facilities were provided at the larger city and metropolitan levels, but they were located in fewer (although seemingly strategic) locations throughout the area of interest. The large city was given four such studios, and 10 studios were provided for the metropolitan area. Further, a trucking service was included and costed to provide program material pick up and equipment maintenance. The number of production centers at the metropolitan level is fewer than would be expected because it is assumed that more material would be purchased than would be locally produced as the system grows.

Tables 114, 115, and 116 show the production costs assessed when applying this system on the local, city, and metropolitan levels.

Distribution

The number of playback machines required was determined in the same manner as for the college audio system, i.e., twice the average weekly program load.

TABLE 114

PRODUCTION COSTS

LOCAL

ITEM	AMOUNT	COST
	Capital	
Master recorders	18	$36,000
Duplicators	2	5,000
Tape splicer	1	50
*Recording rooms @ 64 sq. ft. each	18	21,350
*Initial software, 1000 hours @ $10 per hr.	-	10,000
*Initial teacher training	-	10,000
*Initial operator training	-	7,000
*Initial planning	-	8,000
Test equipment	-	600
TOTAL		$98,000
	Annual Operating	
*Operating & maintenance personnel	-	$10,000
*Teacher training	-	1,000
*Operating personnel training	-	500
*Administration	-	6,000
Replacement spare parts	-	1,000
Consumable supplies	-	100
Related materials	-	500
*Current programming	-	1,000
*Program update	-	2,300
*Research, testing & evaluation	-	1,000
TOTAL		$23,400

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 115

PRODUCTION COSTS

CITY

ITEM	AMOUNT	COST
Capital		
Master tape recorder	4	$ 8,000
Tape duplicator-recorder	4	16,000
Microphones	8	1,600
Portable recorder	4	7,200
Audio control console	4	10,600
Tape splicers	4	200
Test equipment	-	2,400
*Facilities for studios & control room	-	8,440
*Initial software	-	11,000
*Initial teacher training	-	20,000
*Initial operator training	-	7,000
*Initial planning	-	8,000
TOTAL		$100,440
Annual Operating		
*Operating & maintenance personnel		$ 10,000
*Teacher training		2,000
*Operating personnel training		500
*Administration		6,000
Replacement spare parts		1,000
Consumable supplies		100
Related materials		1,000
*Current programming		1,100
*Program update		2,540
*Research, testing & evaluation		1,000
TOTAL		$ 25,240

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 116

PRODUCTION COSTS

METROPOLITAN

ITEM	AMOUNT	COST
Capital		
Master tape recorder	10	$ 20,000
Tape duplicator-recorder	10	40,000
Microphones	20	4,000
Portable recorder	10	18,000
Audio control console	10	26,500
Tape splicer	10	500
Test equipment	-	6,000
*Facilities for studios & control rooms	-	30,340
*Initial software	-	12,000
*Initial teacher training	-	50,000
*Initial operator training	-	14,000
*Initial planning	-	20,000
TOTAL		$241,340
Annual Operating		
*Operating & maintenance personnel	-	$ 70,000
*Teacher training	-	5,000
*Operating personnel training	-	8,000
*Administration	-	10,000
Replacement spare parts	-	10,000
Consumable supplies	-	1,000
Related materials	-	3,000
*Current programming	-	1,200
*Program update	-	2,770
*Research, testing & evaluation	-	1,500
TOTAL		$112,470

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

Therefore, 56 channels are needed at the local level, 10 four-track tape players and 16 dial start one-track machines. The four-track machines are used to play four programs simultaneously and start automatically. The single track machines handle one program each and start when dialed up. As the system was applied to the city and metropolitan levels, the required number of channels increases to 67 and 73, respectively. These channel requirements are satisfied by 16 four-track machines and three one-track machines to provide a 67-channel capability, and 18 four-track machines and one one-track machine to provide a 71-channel capability. The marked decrease in the number of dial-start machines reflects the inability of the system to accommodate individual demands when it grows to these proportions. As in the college system, the four-track machines are started at prescheduled times, and instructors must dial programs on or before the scheduled starting time.

Distribution of the programs from the central facility to the individual classrooms is handled over leased lines. Lines are leased at the rate of one private, voice quality line for every school room in the system. Rates are based on the straight line distances between the classrooms and the central facility and vary throughout the country. For the purposes of this study, the monthly rate of $2.90 per mile per month is used for all three levels. It is quite possible, however, that the rates could change from level to level. In the case of the metropolitan level, the rates might even vary in different sections of the area of application. As the level or system application expands, there is a steep rise in line costs. This is due to a number of reasons. First, the concentration of schools diminishes, and the straight line distances between the center and the classrooms increase. Secondly, the areas are served by different exchange offices of the telephone company. The line would no longer be straight, but would run from one exchange office to another and finally to the receiver. Thirdly, there is often an additional monthly connection fee associated with patching two exchange offices. The line rates that might be encountered in attempting to hook up a whole state on a dial access system would be so high that, in effect, it becomes impossible to achieve. Therefore, state and regional levels are not discussed.

Another major cost item in a large area dial access system is the switching equipment cost. In addition to the other distribution costs, Tables 117, 118, and 119 indicate the magnitude of the costs of switching equipment. The costs estimated here for switching equipment are based on the assumption that there is a slight decrease in per unit cost as the size of the switching equipment increases.

Reception

Reception equipment consists of a dial set and a speaker in every classroom in the area of application. To maintain this equipment, a maintenance crew is retained to service the equipment as requests are submitted. The cost of operating maintenance trucks is included.

Tables 120, 121, and 122 show the reception costs for each area.

TABLE 117

DISTRIBUTION COSTS

LOCAL

ITEM	AMOUNT	COST
Capital		
Tape players	26	$ 10,400
Switching equipment	-	50,000
Equipment racks	-	750
Amplifiers	-	500
Tape storage	-	800
*Installation	-	8,000
*Facility, 800 sq. ft.	-	14,800
Test equipment	-	600
*Initial operator training	-	2,500
*Initial planning	-	8,000
*Expansion capability - extra switching	-	4,000
TOTAL		$100,350
Annual Operating		
*Operating & maintenance personnel		$ 10,000
*Operating personnel training		500
*Administration		6,000
*Leased line costs		38,750
Replacement spare parts		1,000
Related materials		500
TOTAL		$ 56,750

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 118

DISTRIBUTION COSTS

CITY

ITEM	AMOUNT	COST
Capital		
Tape players	9	$ 7,600
Switching equipment	-	500,000
Equipment racks	-	750
Amplifiers	-	1,000
Tape storage	-	900
*Installation	-	80,000
*Facility, 100 sq. ft.	-	18,500
Test equipment		600
*Initial operator training		2,500
*Initial planning	-	10,000
TOTAL		$621,850
Annual Operating		
*Operating & maintenance personnel	-	$ 10,000
*Operating personnel training	-	500
*Administratration	-	6,000
*Leased line costs	-	403,900
Replacement spare parts	-	5,000
Related materials	-	2,000
TOTAL		$427,400

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 119

DISTRIBUTION COSTS

METROPOLITAN

ITEM	AMOUNT	COST
Capital		
Tape players	19	$ 7,600
Switching equipment	-	2,000,000
Equipment racks	-	750
Amplifiers	-	1,500
Tape storage	-	1,000
Installation	-	320,000
*Facility 2000 sq. ft.	-	37,000
Test equipment	-	1,000
*Initial operator training	-	2,500
*Initial planning	-	15,000
TOTAL		$2,386,350
Annual Operating		
*Operating & maintenance personnel		$ 20,000
*Operating personnel training		1,000
*Administration		10,000
*Leased line costs		1,614,000
Replacement spare parts		20,000
Related materials		8,000
TOTAL		$1,673,000

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 120

RECEPTION COSTS

LOCAL

ITEM	AMOUNT	COST
Capital		
Dial sets	464	$30,160
Speakers	464	4,640
*Installation	-	4,640
Test equipment	-	600
*Initial operator training	-	2,000
*Initial planning	-	8,000
TOTAL		$50,040
Annual Operating		
*Operating & maintenance personnel		$ 8,000
*Operating personnel training		500
*Administration		5,000
*Truck operation		1,800
Replacement spare parts		200
TOTAL		$15,500

* These costs are largely dependent upon the actual rate of charge in a particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 121

RECEPTION COSTS

CITY

ITEM	AMOUNT	COST
Capital		
Dial sets	4836	$314,340
Speakers	4836	48,360
*Installations	--	48,360
Test equipment	--	600
*Initial operator training		2,000
*Initial planning		10,000
TOTAL		$423,660
Annual Operating		
*Operating & maintenance personnel		$ 16,000
*Operating personnel training		600
*Administration		5,000
*Truck operation		2,000
Replacement spare parts		600
TOTAL		$ 24,200

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

TABLE 122

RECEPTION COSTS

METROPOLITAN

ITEM	AMOUNT	COST
Capital		
Dial sets	19,330	$1,258,000
Speakers	19,330	193,300
*Installation	--	193,300
Test equipment	--	6,000
*Initial operator training	--	4,000
*Initial planning	--	20,000
TOTAL		$1,674,600
Annual Operating		
*Operating & maintenance personnel		$ 21,000
*Operating personnel training		1,800
*Administration		8,000
*Truck operation		10,000
Replacement spare parts		2,400
TOTAL		$ 43,200

* These costs are largely dependent upon the actual rate of charge in the particular setting, and the degree to which a school system might already be budgeting for these items.

Cost Data Sheets

The following pages are cost data sheets which collect the costs in the production, distribution and reception categories for each area of application. These costs were obtained from the preceding descriptions and tables.

The equivalent annual cost listed on the cost data sheets is a combination of the annual operating cost and amortization of the captial cost. Generally, initial personnel costs and equipment costs were amortized over 10 years, programs were amortized over five years, and facilities over 25 years. Exceptions occur at the college level of application. Television reception equipment is amortized over five years, and both audio and video educational materials are amortized over three years. Interest rates were assumed to be five percent.

Per pupil costs are presented in the table following the cost data sheets.

TABLE 123

DIAL ACCESS (AUDIO) - COLLEGE

PRODUCTION	CAPITAL	OPERATING
Personnel	$16,500	$27,350
Equipment	38,700	1,100
Programs	21,500	9,000
Material		100
Facility	15,500	
Total:	$92,200	$37,550
Equivalent Annual Cost	$53,650	

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 6,500	$26,850
Equipment	115,300	1,100
Programs		
Material		200
Facility	14,800	
Total:	$136,600	$28,150
Equivalent Annual Cost	$44,950	

RECEPTION	CAPITAL	OPERATING
Personnel	$ 6,000	$ 9,612
Equipment	64,700	550
Programs		
Material		100
Facility	86,600	
Total:	$157,300	$10,262
Equivalent Annual Cost	$25,550	

TABLE 124

DIAL ACCESS (VIDEO) - COLLEGE

PRODUCTION	CAPITAL	OPERATING
Personnel	$ 32,000	$127,000
Equipment	135,000	2,000
Programs	20,000	8,350
Material		1,200
Facility	152,500	
Total:	$339,500	$138,550

Equivalent Annual Cost $178,300

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 6,500	$ 28,750
Equipment	197,800	1,000
Programs		
Material		600
Facility	14,800	
Total:	$219,100	$ 30,350

Equivalent Annual Cost $57,800

RECEPTION	CAPITAL	OPERATING
Personnel	$ 4,000	$ 200
Equipment	75,000	1,000
Programs		
Material		
Facility	13,110	
Total:	$ 92,110	$ 1,200

Equivalent Annual Cost $19,970

TABLE 125

DIAL ACCESS - LOCAL

PRODUCTION	CAPITAL	OPERATING
Personnel	$ 25,000	$ 17,500
Equipment	41,650	1,000
Programs	10,000	4,300
Material		600
Facility	21,350	
Total:	$ 98,000	$ 23,400

Equivalent Annual Cost $35,850

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 10,500	$ 16,500
Equipment	75,050	39,750
Programs		
Material		500
Facility	14,800	
Total:	$100,350	$ 56,750

Equivalent Annual Cost $68,850

RECEPTION	CAPITAL	OPERATING
Personnel	$ 10,000	$ 13,500
Equipment	40,040	2,000
Programs		
Material		
Facility		
Total:	$ 50,040	$ 15,500

Equivalent Annual Cost $21,970

TABLE 126

DIAL ACCESS - CITY

PRODUCTION	CAPITAL	OPERATING
Personnel	$ 35,000	$ 18,500
Equipment	46,000	1,000
Programs	11,000	4,640
Material		1,100
Facility	8,440	
Total:	$100,440	$ 25,240

Equivalent Annual Cost $ 38,500

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 12,500	$ 16,500
Equipment	590,850	408,900
Programs		
Material		2,000
Facility	18,500	
Total:	$621,850	$427,400

Equivalent Annual Cost $506,600

RECEPTION	CAPITAL	OPERATING
Personnel	$ 12,000	$ 21,600
Equipment	411,660	2,600
Programs		
Material		
Facility		
Total:	$423,660	$ 24,200

Equivalent Annual Cost $ 79,000

TABLE 127

DIAL ACCESS - METRO

PRODUCTION	CAPITAL	OPERATING
Personnel	$ 84,000	$ 93,000
Equipment	115,000	10,000
Programs	12,000	5,470
Material		4,000
Facility	30,340	
Total:	$241,340	$112,470

Equivalent Annual Cost $143,000

DISTRIBUTION	CAPITAL	OPERATING
Personnel	$ 17,500	$ 31,000
Equipment	2,331,850	1,634,000
Programs		
Material		8,000
Facility	37,000	
Total:	$2,386,350	$1,673,000

Equivalent Annual Cost $1,979,000

RECEPTION	CAPITAL	OPERATING
Personnel	$ 24,000	$ 30,800
Equipment	1,650,600	12,400
Programs		
Material		
Facility		
Total:	$1,674,600	$ 43,200

Equivalent Annual Cost $260,000

TABLE 128

COSTS PER PUPIL -- DIAL ACCESS SYSTEM

	PRODUCTION		DISTRIBUTION		RECEPTION		Total Equivalent Annual Cost
	CAPITAL	OPERATING	CAPITAL	OPERATING	CAPITAL	OPERATING	
Audio College	$13.17	$ 5.36	$19.51	$ 4.02	$22.47	$ 1.47	
Equivalent Annual Cost	$ 7.66		$ 6.42		$ 3.65		$17.73
Video College	$48.50	$19.79	$31.30	$ 4.34	$13.16	$ 0.17	
Equivalent Annual Cost	$25.47		$ 8.26		$ 2.85		$36.58
Local	$ 6.53	$ 1.56	$ 6.69	$ 3.78	$ 3.34	$ 1.03	
Equivalent Annual Cost	$ 2.39		$ 4.59		$ 1.46		$ 8.44
City	$ 0.67	$ 0.17	$ 4.15	$ 2.85	$ 2.82	$ 0.16	
Equivalent Annual Cost	$ 0.26		$ 3.38		$ 0.53		$ 4.17
Metro	$ 0.40	$ 0.19	$ 3.98	$ 2.79	$ 2.79	$ 0.07	
Equivalent Annual Cost	$ 0.24		$ 3.30		$ 0.43		$ 3.97

SECTION G

COST SAVING - TECHNOLOGY ADVANCES

COST SAVING - TECHNOLOGY ADVANCES

Candidate Cost Savings and/or Innovative Media Systems

The objective of this section is to explore innovative media systems which have cost savings potential. Consideration will be given to audio, visual, and audiovisual stimuli as they relate to the student. In some cases, the idea may not be new, but it is not in general use in the educational area. No attempt will be made to evaluate the creative effort and cost required for the initial formulation of the content of the various media. The capability for local preparation of materials as well as centralized mass material preparation and distribution will be identified.

Audio Systems

Audio systems are those systems and techniques for presenting audible outputs to students. Alternative approaches to the problem of distributing the output to the students as well as systems for recording and playing back the information are considered. Emphasis is placed on systems permitting individualized access to the materials.

Random Access Dial Access System. Dial access systems offer a convenient method of distributing audio to a larger audience. Though a communications network is required, a central location containing recorded programs and playback equipment can serve a large audience without the necessity for multiple copies of the programs. The majority of present systems, however, do not take advantage of the inherent freedom which a dial access system provides. In most existing systems, the programs are available on a fixed schedule; the student must access the system at precisely the right time to start a given program. If he is late, he misses the beginning of the program; if he is early, he must wait to start. Personnel are required at the central location to load programs and start the playback equipment at the appropriate times. A significant improvement is possible if the system provides the capability for random access; that is, a student can access any of the programs contained in the system at any time convenient to him, and, without undue delay, receive the desired program from its beginning.

One system currently available provides this capability. Any of the programs stored on a library or memory bank tape player can be accessed with a minimum time of 30 seconds and a worst case time of 60 seconds for a 15 minute program. Each independent access to the system requires a separate playback unit. Unfortunately, the system is relatively expensive.

Another technique which is presently unavailable commercially appears capable of offering the advantage of random access at a lower cost. Each audio program, using individual playback equipment, can be accessed by an unlimited (except by the dial access communication network capacity) number of students. Each student starts at the beginning of the program independent of the time or number of previous accessions. The initial accession has no delay; subsequent accessions have an average delay of 60 seconds. The delay interval can contain supplementary information such as program identification and the time until the text begins. Thus, the student is immediately reinforced with the knowledge that the correct program has been accessed and that the text will start within several seconds. A manufacturer's estimate of the sales price for such an equipment is of the order of $1500 to $2000. The number of units needed is equivalent to the total number of programs which must be available simultaneously. The cost of the communications network is additional, and is strongly dependent upon the topography of the network.

Audioactive-Compare Dial Access Systems. The standard dial access systems, such as described above, are passive. The student can only listen although, in the second system described, he can backspace and repeat program segments. In some instructional tasks, the student can benefit from an audioactive-compare capability which allows him to listen, record, and compare.

An economically attractive approach to adding an audioactive-compare capability is to provide students with a separate portable two-channel tape recorder. In operation, the student accesses the desired program via a random access dial access system and records the material on one track of the portable tape recorder (price - $50 - $75). While the program is being recorded, the student can do other work. When the recording is completed, he can use the tape in place or carry it to another location (dormitory, etc.). The tape in the student recorder may be reused, which avoids the necessity of acquiring and maintaining a large inventory of program copies.

Should the use of audioactive-compare programs be widespread, the time required to rerecord a program may be reduced by high speed playback/record. One limit to the amount of time which can be saved is the bandwidth of the communications network. Typical commercial subscriber lines have a bandwidth of approximately 3000 Hertz. Acceptable fidelity requires at least this bandwidth. Should the communication network used in the dial access system have a bandwidth of 6000 Hertz, double speed playback/recording will result in a 50% reduction in on-line time without any deterioration of fidelity. In general, the product of communication line bandwidth and rerecording time must be kept constant to preserve fidelity of normal speed playback.

An additional benefit available from high speed rerecording is a reduction of the occupancy time on the network, thus enabling a larger population of users to receive service. The cost trade-offs for the general utilization of such a system are somewhat complex and are beyond the scope of this report.

Individual Audio Source Systems. Audio offers an opportunity for low cost individual use media. Both magnetic tape and records (or disks) are excellent methods for providing unregimented and unscheduled audio materials. Magnetic tape has two principal advantages - ease and low cost of providing locally produced and/or limited copy audio. However, magnetic tape offers these advantages only when less than 50 copies are required. Beyond this point, disks become increasingly competitive. Moreover, this comparison is based upon the cost of a magnetic tape on a reel. If the magnetic tape is loaded into cartridge or cassettes so that their ease in handling is comparable to disks, then the cost for tape must be increased by $ .30 to $1.00 to include the cost of the cartridge. When the number of copies increases to approximately 30, the cost for the cartridge equals or exceeds the cost of the record. The above is based upon 50 minutes of audio and 500 foot magnetic tapes versus 7" records.

Perhaps the major reason for the present disfavor of records is that conventional record players are inconvenient. The typical configuration of turntable and arm with manual loading is somewhat difficult to use and is easily damaged, particularly in an elementary school environment. However, slot loading record players have been designed and are available. The record is inserted into a slot in the front of the machine and is automatically played. Operation requires no more dexterity than is required to mail a letter. Designs are available for a slot loading player suitable for playing the embossed vinyl disks which approach a unit cost of five cents each in production quantities. These disks have the fidelity of the conventional rigid disks and are capable of more replays (250) before any degradation is noticeable. Even greater savings are available if a 4" record is used to provide a 10 to 15 minute program. In quantity production, the cost per record approaches two cents.

Acoustically Driven Slot Loading Record Player.* It is well within the state of the art to design a slot loading record player in which the only electrical part is the drive motor. The record can be cut with vertical modulation rather than the conventional lateral modulation. This can be done on a conventional stereo cutting lathe by driving both channels with the same signal. The stylus may be made to drive a plastic pnuematic chamber (somewhat like a bellows or the old gramaphone) which in turn drives stethescope-like headsets. The headset suggested is presently in common use in aircraft sound systems and consists of a pair of hollow flexible plastic tubes leading to the earpieces. Provision may be made for plugging in several headsets to permit multiple users. What is envisioned is a package consisting of perhaps 100 records in a box approximately 5" x 5" x 15" and one or more slot loading acoustically driven record players available for each classroom. The record jackets would contain visual and textual materials complementing the audible material on the records. Students would use these, much as the present SRA series are used, either for enrichment or at the teachers' direction, individually or in groups. It is entirely reasonable to anticipate the sales price for 100 such records would be in the $30 to $50 range (production costs less than $10). The record player should be producible to sell profitably at a price of $15 to $25. It could be powered either from the 60 Hertz power line or with self-contained rechargeable batteries so that a student might take a record and the player from the side of the room to his seat as he wishes. A broad base of use would permit the development of a rich repetoire of materials which could be made available at a realistic price. It presents an opportunity to augment and enhance the visual materials presently available with the SRA series and economically permit a much higher degree of individualization of instruction.

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* The commercial availability of a similar device was recently announced. See Bakelite Review, April 1968, pp 8-9.

Audio Program Dissemination Via Existing Classroom TV. In many schools, off-the-air television receivers which exist in the classroom may be utilized to provide additional audio programs under teacher control to individual classrooms for a small additional capital expenditure. Two approaches and their approximate cost are described.

In the schools already containing classroom television, it is possible to provide audio programs by using the unallocated television channels of the receiver. Assuming (as is frequently the case) there is a master antenna system supplying off-the-air, or local (VTR, studio, etc.) television signals to the classroom receivers, audio programs may be fed into the master antenna cable and selectively received in the classroom while the screen remains blank. This requires an r.f. oscillator and modulator (price less than $100) for each television channel to be so used. Teachers can schedule the playing of a specific program from any audio source and, at the appropriate time, "tune it in" on the normal, unmodified classroom television receiver. Any or all of the receivers in the school may listen to the program. Thus, the capabilities of a single audio source can be extended to every classroom in the school at a total cost of less than $100.

Greater flexibility, indeed the full capability of the audio source, may be extended to the classroom with the addition of a remote control start-stop capability. The teacher could then have an audio program loaded into the player at the master antenna location and available for use over a given time frame - perhaps one or two hours. At any time during that interval, the classroom television could be tuned to the appropriate channel and the audio source would be completely under teacher control via the start/stop remote control.

Such a remote control capability could be most economically realized with a carrier current type system. The transmitter (in the classroom under teacher control) would send coded control signals into the power line. These would then be received and acted upon by the receiver plugged into the same power line at the audio source location. No additional wiring or installation are required for this technique. It is similar to the technique used in "wireless intercom" systems that are advertised in the Allied Radio Catalog - 1968, at prices from $20 to $60 per pair. It is entirely realistic to estimate the cost for such a remote control system at $35 for the receiver (only one required) and $30 for the remote control unit (number required is determined by the desired ease of use).

Multiple Channel FM Transmission. The present channel bandwidth allocation for FM is 100K Hz. Approximately 40K Hz is occupied by a stereo broadcast. A single FM channel can be used to broadcast four independent channels simultaneously - one stereo pair low band, one stereo pair high band. This is somewhat similar to the techniques in use in some public/private service FM stations.

A standard FM-stereo receiver can be used to receive the programs. Reception of channels 1 and 2 (low band) would not require any additional equipment. Reception of channels 3 and 4 (high band) would require the addition of a special module which should cost less than a standard receiver.

An alternate use of this technique would be to piggyback educational programs on the unused spectrum of commercial FM stations. The normal band commercial service would be unaffected by the presence of the educational material on the high band.

Two approaches to implementing this technique at the transmitting station are:

1. To add the necessary subcarrier oscillators at each transmitter station; or

2. To use a wide band magnetic tape recorder to playback material previously recorded using the subcarrier oscillator of 1.

The first approach requires special equipment at each transmitter location. The second technique requires this equipment only at one location where master tapes are created. The cost effective choice is dependent on local conditions.

Induction Loop Audio Dissemination. The use of audio materials requires either a loudspeaker or headset for the dissemination of sound. If a loudspeaker is used, everyone must listen. If headsets are used, relatively expensive wiring is required and the student is tethered to one location by the cord. However, if an induction loop is used, a headset may be connected to the audio source in place of the loudspeaker so that only those students using special headsets without any connecting wires will hear the program. Thus, any desired area, ranging from a table to a complete auditorium, may be covered.

The recently announced GRAFLEX^R system provides the special headsets at a cost of $24.95 each and audio loops with a pressure sensitive adhesive for installation at any location costing from $19.00 for a table top size to $26.50 for a 1200 square foot room size. Extension loops to cover additional areas of 1200 square feet are $16.75.

Through the use of such an induction loop system, the audio portions of television programs, tape and record players, and motion picture programs can be made available to selected members of a class while others are pursuing different activities.

Visual Systems

A major cost element in visual media systems is associated with the necessity of acquiring and distributing inventory copies of the visual materials. The recent development of relatively inexpensive magnetic disk recorders offers a means of reducing these costs. A recently announced video disk recorder (price unavailable but estimated at approximately $1,000 to $1,300) has a capacity of 360 television frames. These frames are each located on concentric circular tracks and are accessed by a single indexing magnetic head. The tracks (or frames) may be played back (or recorded) in real time, providing up to 12 seconds of normal motion; in slow time, providing up to 12 minutes of slow motion; or accelerated motion through the use of appropriate recording techniques. The particular feature to be utilized here is the ability to playback stop motion, and play and display a single track continuously for as long as desired.

A method of reducing the inventory and distribution costs of still visual materials is to use a video disk recorder to store and playback the desired visual frames through a television receiver. A library of visual materials is maintained at the local on-the-air ETV station. A teacher desiring visual materials would identify the set desired in a catalog and call the request into the ETV station. At a prearranged time the visuals would be broadcast. The teacher (or local AV specialist) would receive these on a normal television receiver and record them on a video disk recorder located in the school. The materials can subsequently be played back under teacher control through the classroom television receiver.

Greater flexibility and lower cost can be achieved by using the technique previously described using an r.f. oscillator modulated by the video output from the disk recorder which transmits into the master antenna distribution cable on unallocated television channels. By using the carrier current remote control, the teacher can at any desired time start the display and advance or reverse the still frames displayed on the classroom television receiver.

Although only one frame can be played back at a time, any number of television receivers can view that frame. The 360 capacity of the particular unit under discussion (Panasonic Video Speed Recorder) suggest that more than one program can be stored on single magnetic sheet. Assuming an average program size of 30 frames, a single unit can be programmed to serve 12 teachers. It should be pointed out that the magnetic sheets are both erasable and reusable as well as easily demounted and stored.

To estimate the time required for the off-the-air distribution of visual materials, the minimum possible time will be calculated and then increased to allow for handling problems. The video recorder can record a single frame in 1/30 second; 360 frames require a total of 12 seconds. Assuming 48 seconds are required to identify the program as one to be recorded and an additional 30 seconds to terminate the recording, 360 frames can be broadcast to a school and manually recorded in 90 seconds. The broadcast time required to distribute 10 independent programs throughout the service area of the ETV station is 15 minutes.

For a relatively small additional cost, the entire process may be automated and the distribution time significantly reduced. One approach to automation is to assign a code to each school. The code of a particular school would be broadcast prior to the start and stop of broadcasting the visual materials directed to that school. This would start and stop the video disk recorder. A simple means of doing so is to use the audio channel to broadcast coded control tones, a common practice for low cost remote control systems. The distribution time would now approach the limiting 12 seconds per 360 frames of visuals or 300 programs of 360 frames each in one hour. It is difficult to imagine a requirement for more than one hour of broadcast time per day to disseminate visuals throughout the service area of an ETV station.

Audiovisual Systems

Systems which provide both visual and audible stimuli to the student are undoubtedly the most effective, but are also the most expensive. To present a 15 minute motion/sound program using standard projectors requires approximately 400 feet of film. Although some of the material on film requires motion to carry the message, much of it does not. Children have been trained, particularly via comic strips, to read motion into properly drawn stills. On this basis, it is suggested that a substantial portion of material presently on motion picture media can be placed on a still projection system with synchronized sound. To substantiate this point, the obverse has been done with great artistic success in commercial films such as "Michaelangelo". However, as always, talent and imagination will be required to make such media truly effective.

Film Strip and Synchronized Audio Source. A relatively low cost audiovisual system can be realized through the use of an audio source which also provides the film advance signals to a film strip projector (or automatic slide projector). Either records or magnetic tape may be used to provide the audio and film advance signals. In either audio source, the choice exists whether to use one or two channels, one for audio and the other for film advance. The two-channel approach would tend to be simpler and more reliable at approximately the same cost. For programs which are to be locally generated and with limited copy requirements, magnetic tape is the logical choice for the audio source. For programs with wider distribution, stereo records (one channel for audio, the other for film advance) are significantly less expensive. Ignoring the authoring and/or mastering costs, the cost per unit of records (7 inch @ 16 2/3 rpm - 50 minutes of audio) and magnetic tape (reel, not cartridge - 500 feet @ 3 3/4 ips - 50 minutes of audio) are equal ($2.70) when 42 copies are required on a duplication cost basis. For less than 42 copies, magnetic tape is less expensive. For more than 42 copies, disks are less expensive with costs per unit of approximately $1.40 in quantities of 100 and 18 cents in quantities of 1,000 and more. Relevant cost factors to be considered include the present availability of suitable players and the cost of purchasing record players versus tape players. The latter are more expensive. In either case, a black box must be purchased to translate the electrical film advance signal from the audio source to an appropriate form for operating the projector. Many designs are available; none should be particularly expensive (approximate cost $50).

To compare production costs, assume a 15 minute program. With a super 8mm sound system, this would require approximately 250 feet of film at a typical production cost of $12.50. The same material presented on a still projector with synchronized audio would require one record at 18 cents and approximately eight feet of 35mm film at a cost of approximately $1.00. The frames are assumed to be presented at an average viewing time of 10 seconds each permitting some sequences to go at a staccato rate in order to better approximate motion. Present motion picture materials may be used as the source for the film strip/audio, thereby significantly reducing first time costs.

Integrated Audiovisual System

A system which is relatively economical and more suitable to individualized presentations and self-pacing as well as group presentations has recently been evolved. A breadboard model has demonstrated its feasibility. In this system, both the audio and visual information are placed on a common film medium. Visual and sound are irrevocably synchronized. Each visual frame has an associated audio frame which may be repeated as often as desired while the visual frame remains unchanged. The advance to the next audiovisual frame requires but a fraction of a second. One hundred feet of "film" has the capacity for approximately 2400 visual frames with up to either four hours or 20 hours of audio depending upon the final production technique. Magnetic recording which yields up to 20 hours of audio is recommended for programs requiring a relatively small number of copies or for those which will be produced locally. Those programs requiring a large number of copies might best be produced with optical sound which would permit one pass duplication of audio and visual materials, but which will limit the total content to approximately four hours.

The medium can be coded so as to permit slewing at fast rates to different segments. Mechanically, a 400 foot program length is completely practical. The 9600 frame/80 hours of audio in addressable segments could provide a rich source of material in a unitized package requiring little reloading with new programs. The sales price has been estimated to be approximately $1000. The major problem in utilizing such a device is finding an adequate supply of good pictures and sound to fill even a single role of the medium.